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ADDRESSES

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Address of Dedication.

By President David Starr Jordan,
Leland Stanford Junior University.

To each century is granted one great discovery, and from this its highest thought and action take their bent. In each century this discovery is never a new one. It has had its prophets and martyrs—ages before—men whose lives have seemed to be thrown away until at last the world moves on and the caravan reaches their point of vision.

The great discovery of the eighteenth century was that of the humanity of man. In action, this became the spirit of democracy. The great discovery of the nineteenth century was the reality of external things. Carried out into action this means the progress of science. It is the movement of science which makes possible the varied activities of the new twentieth century.

We are gathered together this morning of the twentieth century to dedicate a new hall of science, a new temple to the worship of the truth of nature. It is erected that it may help men to know, and to know what they know—to separate their knowledge of realities from their feelings, their hopes, their dreams, their traditions. All these may be beautiful, helpful, inspiring—but truth is something more than subjective satisfaction. To that part of the divine outside ourselves which we are able to attain we give the name of science.

In what I may try to say this morning, I shall speak freely in praise of science, of science study and science teaching. It is for this that we are gathered together. When we erect the hall of the poets, then our discourse may be on Euripides and Shakespeare, on Schiller and Browning, and some gentler tongue shall speak the fitting word.

Each power of man shall be exalted in due season and no one at the expense of another. It is true that science is a late comer into the educational household. Finding none too much room at the best, she sometimes unwittingly ventures to claim it all. But that is only for the moment. Knowledge of man and knowledge of the universe do not exclude each other. In urging the claims of science we would not deny one word ever said for training in the humanities or in any branch of these. This only would we claim, then, there exist forms of culture other than those which rest on the classical tripos. Other men with other powers have an equal right to training. There is no aristocracy in the human mind. Moreover, prescribed courses of study, whether classical or scientific, or whatever else they may be, must give way to the needs of individual training. Ready-made clothing—even though it take the form of heroic uniform—does not guarantee a fit. The needs of modern life demand actual fitting. The best training is that best adjusted to our own individual needs

I am told that Colorado College is one which aspires to be "only a college," a thoroughly good college, of course, but that she has no thought of becoming a university. I do not learn this from my friend, Dr. Slocum, and I know that his ambition is boundless. But whether it be true or not, I am going to oppose the idea. She will be a university before you know it. This Palmer Hall may be offered in evidence that the college period is past. Colorado College is already become a university. A university in embryo, perhaps, if you like, but still with all the marks by which the university is known—as certain to become a university in fact as a pine seedling on your royal hills is sure some day to become a pine tree.

A university in America is a place where men think lofty thoughts, where men test for themselves that which seems to be true, where men find their life work, where men go up to the edge of things and look outward into the great unknown.

The university does not consist of colleges and departments, deans and dignitaries, rules and regulations. It is not a cluster of professional schools, nor even a group of graduate students. Its spirit is not measured by printed theses, by elaborate examinations, by the number of the hoods of black and gold its doctors are privileged to wear. It is measured by the animating spirit, the spirit of intellectual enterprise, of academic devotion. This spirit will in time create for itself the brick and stone, test tubes and microscopes, books and manuscripts, all the machinery with which a university must work.

In the development of an animal there is a subtle influence, which we cannot measure, always at work, and working to the end that the embryo becomes at last that which from the first it was fated to become. We call this the influence of heredity, but to name it leaves more to be explained than there was before. In like fashion, the spirit of the university, the spirit of zeal and devotion, of beauty-loving and truth-fearing which is in Colorado College today will make the university an accomplished fact. Truth-fearing—there is no better phrase—truth-fearing is the spirit of the university.

There is no real difference between the American college and the university and there will never be any. The lower achievement cannot refrain from the higher ambition. Many colleges are little, or weak, or lean, or narrow universities; yet even the poorest of them may be hallowed by some one's devotion, ennobled by some one's scholarship. It is scholarship and devotion which in the long run make the university. Certain genuine attributes of the true university we may see clearly in Colorado College. For one thing, she is broad-minded. The hall we dedicate today stands as one evidence of this, her fair library is another, and still more cogent, the wide sympathies and helpful achievements of her professors.

I believe most firmly in the educative value of unlikeness in aim and thought. A man may be highly specialized, he must be, if he would succeed as an investigator; but a university should be an all-round organism. The school of applied science, the school of literary expression, should not stand apart from each other. The engineering student is likely to become illiterate if he herds only with his kind. He learns many lessons from the finer side of life, from the student of Chaucer or Homer. The literary student tends to become a dreamer or a prig if he is in touch with literary matters only. From the fierce earnestness of the young engineer, whose whole career depends on the soundness of his individual work, the student of the humanities gains most valuable lessons.

For the same reason I believe in the co-education of men and women. They need not study the same things, though for the most part, as beauty is beauty and as truth is truth, so mental accuracy knows no distinction of sex. But the influence of wise and cultivated women works for manliness and refinement. The influence of hopeful and strenuous men gives women's work a seriousness and sanity which is a fair exchange for the other. Where co-education is honestly and rationally tried, it is no experiment at all. In the natural order of things, and in the long run, the American university and every other real university will be a school for men and women, opening its doors to all who can use its advantages or who can share its ideals.

Wherever there is a real scholar—independent, self-reliant, truth loving—there we have a university. He gives the university uplift, the university inspiration, the university ideal. If he has but one student, that one is a university student. I do not know how many such there be in the faculty of Colorado College, but there are some I know; some peaks which catch the morning sun, and in the presence of these we have the essential element of the university.

In the American scheme of education, the college course is a period of intellectual broadening. It makes men, while the university makes scholars. The German university system admits of no college course. The rigid drill of the gymnasium, intense and narrow, gives way at once to the university, where any subject can be pursued in any fashion or in no fashion at all. The gymnasium has cast-iron walls. She takes no account of individual differences; she will "drill but not create." The university is wide open, everything is at the student's hand: science, letters, art, lust or beer. The student chooses for himself, and the university, as an organism, is indifferent as to his choice.

The American university cares for its students, unwisely sometimes, in nagging or futile fashion, but still on the whole to their great advantage. She is always a cherishing mother, and as such she is beloved by her children. I have never heard a German university called "Alma Mater." "Liebes narrisches Nest,"—dear, silly nest,—this Goethe once called Jena, but Jena was held in remembrance not for her loving care, but for the fond follies she uncaring allowed her sons to perpetrate. The

German university makes no effort to see that her students work wisely, or indeed that they work at all. They are weaned, once they leave the gymnasium. There are too many of them anyhow. The most of them go to swell the "intellectual proletariat" which, so the Germans tell us, with the military proletariat is a national menace; what then does it matter?

Bismarck is reported to have said that one-third of the German students drink themselves to death, one-third die of overwork, and the rest rule Europe. In America, the college has tried to change these proportions; college professors have thrown their personal influence to induce young men to lead sane and profitable lives, to keep them from throwing away their future till the time comes to rule. In this work the faculty of Colorado College have long taken an honorable part. They have shown the value of personality; men are saved as much by fellowship as by precept or practice. By personality is built up the college atmosphere, the "fellow feeling among free spirits," an agency in higher education as subtle as it is effective. For this reason the value of the college depends largely on the nearness of the professors and students. "They knew each one of us by name:"—this has been declared as the secret of the education of old Japan. Not professors, not masters, not martinets of high or low degree, but men who were fellow students have been the most successful teachers. The value of a teacher decreases with the increase in the square of the distance from the student. In this matter the smaller universities have a great advantage over the larger ones if they will only be as careful in the choice of teachers. Only those who are near him know that a teacher is great. There are many graduates of our strongest institutions who never in their whole four years came in contact with a professor. Not long since, the editor of an Eastern magazine, an able student and a man of strong character, told me that in his college course he had a speaking acquaintance with but one professor. There were a hundred in the faculty, many of them men of high distinction, but what was that to him? His work was laid out for him in a prescribed course, long before he was born, and from young instructors he received all his guidance.

In this lies one value of the study of science. It has but one method, that of the laboratory, that of first hand contact with things as they are. The teacher himself is part of that contact. He has set the problems, arranged the experiments. The teacher of science does not speak *ex-cathedra*. He must come down from his chair. He must be among the things of which he speaks, and to the student he must be part of them, and the student knows him as he knows them—from personal contact. The strength of the colleges of England has lain, not in the narrow courses of study, not in the exclusive pursuit of Latin, Greek and Mathematics, but in the spirit of good fellowship which these institutions have fostered. The life of the student is a man to man life, the element of personality has been used to the utmost and with results which need not be disparaged even by those most impressed with the narrowness of the training these colleges offer.

The aim of Oxford and Cambridge has been personal culture. The classical tripos of Latin, Greek and Mathematics has been only a means to this end. Any other studies—Anglo-Saxon, Botany, and Medieval History, let us say—would do as well if equally removed from the current of human activity and brought as close to living personality. Merely intellectual training was no essential part of the process. To withdraw for a space in the presence of good men and gracious thoughts is an ideal cherished in English culture. "Sometimes to bask and ripen," Lowell tells us, "is, methinks, the student's wiser business." For the maturing scholar this may be true, but as a practical matter it is surely a universal experience that to the college student "to bask and ripen" means a period of plain idleness, and idleness soon turns to dissipation and vice. It is better for the student that demands on him be somewhat strenuous. His life is made more effective if he has once learned the value of time and the necessity of doing things when they should be done. A man who has not learned the worth of time before he is twenty-one seldom accomplishes much afterward.

As the university ideal of England is one of personal culture, that of Germany is one of personal knowledge. In the one case, thoroughness is the essential, in the other, personality. An educated German may lack culture—of this there are many conspicuous examples—just as in England a cultured gentleman may lack exactness of knowledge on all points. In America a new ideal is arising as a result of the creative needs of our strenuous and complex times. We value education for what can be made of it. Our ideal is personal effectiveness. We care less and less for surface culture, less and less for mere erudition. We ask of each man not what he knows, but what can he do with his knowledge. This ideal of education has its dangers. It may lead us to sacrifice permanent values for temporary success. It may tend to tolerate boorishness and shallowness, if they present the appearance of temporary achievement. Eternal vigilance is the price of scholarship as well as of liberty and other good things.

But the fact remains, the value of science lies in its relation to human conduct. The value of knowledge lies in the use we can make of it. As each thought of the mind tends to work itself out in action, so does each accession of human knowledge find its end in fitting men to live saner and stronger lives. We may therefore rest content with the ideal of effectiveness. The American scholar is master of the situation. He can make things go, because he understands them and still more because he understands himself. He does not shrink from that which appalls the man of culture. He is adequate for that which bewilders the erudite. Judged by our best products, there is no finer man on the earth than the college man of America, and in proportion we shall do better by him in the future than we are doing today.

In mechanics we know that the force of a moving body is not measured by its substance. Its momentum or effective power is found in its weight multiplied by its speed. This illustration has been used in praise of American science. The power of science lies not in individual erudition. It lies in its striking power. American science is dynamic; it is always under way. Its weight must be multiplied by its active force to give its real value. In every branch of science, the best American workers have been those most strenuous in their personal efforts, most eager to make their work useful to the world at large. In almost every branch of utilitarian science America already stands in the lead. This fact England has already recognized with dignified dismay. We hear much of it now, we shall hear more of it still later, for quite as remarkable as the advance of American science is the advance of American schools of scientific instruction. Whenever I visit a department of applied science in America, I see that it has doubled its power, its staff and its equipments since the time of my last visit. My visits are not very frequent, perhaps once in five or ten years, let us say, but what will be the end of it? To double once in fifty years is a rare thing in the universities of the old world, but even that in a few centuries would accomplish wonders.

It is one of the laws of life, that a geometric progression will long outrun an arithmetical progression. Whatever increases by doubling will far exceed the bulk of additions. American science and scientific schools increase by doubling and will continue to do so. Hence we measure them not by their actual achievement but by the certainty of their future, far beyond the dreams of those, who, like ourselves, must be numbered always with the pioneer. To lay the foundation of science, the foundation of knowledge, the foundation of the future commonwealth of Colorado, the pioneer has a glorious part to play, but the actuality of the future will surpass the brightest dreams of today. Let us glance at some of the varied thoughts this enterprise suggests.

A hundred miles away at the foot of these same mountains lies your sister university, the official child of the State. It is for you and for her to work in unison, the same in final purpose, somewhat different in the way of reaching it. The most wonderful thing in educational developments since Alfred founded Oxford and Charlemagne, Paris, has been the rise of the state universities of America. These are schools established by the people, paid for by the people, built for their own good, limited by no tradition, but rising in power and usefulness with the rise of the common man's intelligence and wealth. Great men have built them, but they were not kings, nor millionaires, nor politicians, nor priests. They were simply teachers, with the common man behind them. The material support of the University of Colorado is the personal interest of the many. The support of Colorado College is the intensive interest of the few.

The word *intensive* suggests the nature of her opportunities. The state university must concern itself largely with the developments of the professions as a whole, the general intellectual welfare of the State. Every citizen has a stake in it; each citizen has the right to make a demand.

The independent college can make its own clientage. Colorado College is not confined to Colorado. It may be cosmopolitan: its mission is not merely to raise the level of professional work or intellectual life in Colorado; it can aim at higher results, though they be less broad:—to give the exceptional man or woman exceptional opportunity, through the use of the finest agencies within a narrower field. Along the line of this purpose lies the future of the privately endowed colleges and universities. We may not do all things worth doing, but we can do some things better than the state universities can, by virtue of our independent position.

The superiority of the independent college must be real—so far as it goes. It may lie in research, in excellence of teaching, or in the loftiness of personal influence. If its range is not so broad, it may rise higher. It may come closer to the heart. A center of intellectual refinement, a temple of God-fearing and truth-loving men, Colorado College has always been. Here exceptional men and women will find exceptional welcome with exceptional care.

I could not be a son of my own fair State—a "native son" by adoption—did I not say a word as to the glorious climate which Colorado College may add to the roll of her advantages. Here in Colorado, as in California, Nature is kind to man. The weather never makes him its slave, never shuts him up to stew in over-heated rooms. Colorado, like California, is a virile State—one of "Earth's male lands," to adopt Browning's classification. It has, like California, the three splendid attributes of healthful air, magnificent scenery and physical and mental standing room. It breeds independent, all-around men. Colorado flows red blood. It has the out-of-doors atmosphere—free from the narrow, cramped public opinion born of overheated houses, the public opinion of the village of white houses and green blinds, where everybody knows everybody's business. Colorado has the public opinion of the man who stands on his own feet, cares for his own needs, is sufficient unto himself and has the large charity which sound nerves ensure. The way of Colorado is the warrior's way—"the Bushido," as they said in old Japan—the way of the Rough Rider, the way of the strong arm and the tender heart, which cares only for what men are, and not at all for what men say.

Weak men, kept good in the East through the upbraiding of maiden aunts, often fail in Colorado. Good men grow better, for they must fight for and justify their virtue; and after all, that is the only kind of righteousness that counts—the vast, burly, aggressive righteousness to which sin is folly; selfishness and vice, things to be avoided as contemptible as well as shunned as wicked. The scholar in Colorado partakes of the largeness of his field. The dim-eyed monk, the stoop-shouldered grammarian—these are not his ideals. The scholar is the leader of enterprises, the builder of states.

The air of Colorado is charged with oxygen; it is good atmosphere in which to bring up a boy. In Colorado he becomes an out-of-door man. He expands his chest; he can do things; he becomes fearless, because he is adequate. Here in the West we send our graduate students to the East, because we know that it will be well for them to know what their father's home was like. They need New

England acquaintanceship, English culture and German methods of thought. Far more does the Eastern graduate need what the West can give. The life in the foot-hills makes, if need be, a man of the Harvard doctor of philosophy. The world beyond the Missouri spreads his horizon and the swift oxygen in the Colorado sunshine swells the size of his heart. Some day men will go to Colorado and California for the inspiration of force as poets go to Greece for the inspiration of beauty.

The new America is born where things are broad and free and her finest inspiration where things are grand and strengthening. When the days of the emigrant are over, and our people reach their equilibrium, the home of the highest education will be to the west of the Missouri.

Whoever has known Colorado and the West will all his life long hear it calling, and wherever he goes he will carry with him a fuller heart and a freer hand for his life in the plains or the foot-hills, for his life in the regions where the very heavens are cosmopolitan.

I might say a word on the field of local scientific study which Colorado offers. The problems of the local geology have been discussed by my colleague President Van Hise. A region as vast as the Mississippi valley has been crumpled and folded in the stress of the earth to make Colorado. Noble scenery is the raw material of geology. A mighty cliff is an uncovered record of primeval history. In all this history, from the earliest to the latest, Colorado has something to say. The graves of our earliest ancestors, it may be, lie in the hills of Canon City. In these rocks at least are found the earliest traces, the earliest by a million years, perhaps, of any backboned animals. From these it is a far cry indeed to the shales of Florissant, where in their day the earliest birds went out to catch the latest worm there was, and again to the Green River shales of the northwest with their extinct creatures not very different from their descendants of today. When we speak the magic names of Uncompahgre, Ouray, Telluride, Las Animas, Sierra Blancho, Pike's Peak, Long's Peak, Gunnison, Manitou, Saguache—I know them all and know them well—we raise a thousand memories of grand scenery, rich mines, geological problems, the crumpling of continents, the wash of great rivers.

The botany of Colorado runs rampant over all the hills, columbines and gentians, primroses and poppies, sunflowers and lilies; mountain and plain, Colorado is a land of flowers, and better than this, it is a land of problems. Where did they come from? How did they get here? How did they, why did they change? What relation had the movements of the flowers to the vanished glaciers which have left their imprint in lake and moraine, in erratic and sheep-back and furrowed rock, over so much of the surface of Colorado?

In zoology there is equal richness of forms and equal wealth of problem. How came the trout to move from river to river, changing its spots with every change of stream? How did it pass from the Missouri to the South Platte without reaching the North Platte? How from the Platte to the Arkansas with scarcely a change of any kind? How from the Arkansas to the Rio Grande with changes that every angler notices? How again from the Rio Grande to the Colorado? How from the Colorado across the main divide to the Twin Lakes of Leadville? These are problems worthy of a Sherlock Holmes, and the methods ascribed to that mythical personage are the ordinary methods of science. The same process is used but it is turned to a higher end than the hunting down of human sins and follies. The problems of geographical distribution, their facts and the causes which lie behind them.

occupy a steadily increasing place in the world of science and for the study of very many of these problems there is no field so promising as Colorado.

I cannot close this address without a word in praise of the honored president of Colorado College. It is the highest duty, the noblest privilege of the president of the college to give the institution its personality. Others may give money and buildings, the state may create machinery by which the college works, it remains for him to make it a living person, an *Alma Mater,* an influence in the formation of character and citizenship. Sixteen years Dr. Slocum has struggled for Colorado College. Sixteen years of courage, devotion, persistence of a type few other colleges have known. He has sought far and wide for good men, for men of his kind. He has seen richer institutions draw these men away, and then he has begun his search once more, and each time he has closed the ranks with men of the Colorado Spirit. Every great university has been enriched by men drawn from Colorado College. Greater institutions have stood ready to bid for his own services, and in no mean fashion. This I know well, though not from him. But he will not leave the work of his life to begin another, simply because the other stands in a larger yard. There is gold in Colorado, there is silver, there is untold wealth in her mines. But Colorado is not made by mines. She has been made by men. She has had many red letter days. This twenty-third day of February, 1904, is not the least of them all, but none has been fraught with greater hope to the state than that day sixteen years ago, that day when William Frederick Slocum came to the presidency of Colorado College.

The building we dedicate today is called Palmer Hall. It is in a large degree the gift of General William J. Palmer, and it rightfully bears his name. I never met

General Palmer personally until yesterday, but I have long known his name as that of one of Colorado's most enlightened citizens. I trust that he may live long to see his noble gift used and appreciated.

There is no way, I believe, in which accumulated wealth can be so wisely used as in the endowment or enrichment of colleges. In no way can the present secure such pledges of the future, and no gifts are so unselfish as those made to posterity. All who help to promote scholarship, citizenship, efficiency, are patriots in the highest sense and their patriotism should be appreciated by the people.

In all the range of mean-spirited criticism there is nothing more contemptible than that which ascribes selfish aims to wealthy men who give to colleges. Sensationalist neurotics are constantly in fear that the rich man will force the college to teach his doctrines. Such a thing has never happened, for it requires brains to acquire wealth and this implies sense enough to understand the freedom of the university. No rich benefactor of our day has ever tried to use a university as a tool; no one ever will try. Yet the clamor having this as a burden goes up from one end of the country to the other. Over the shoulders of the college the blackmailer tries to stab at the millionaire. But he goes on his way unmindful, and if he be generous-minded, he makes his gifts just the same, sure of the results of the future, even though denied the gratitude of the present.

Here in Colorado there rules a saner spirit. Our Palmer Hall is the gift of a kind and helpful friend. As such it is received by all who are here today and by all true and loyal citizens of Colorado.

Finally, let me say: In all plans of university building there is but one that succeeds. Those who do original work will train others to do it. When teachers are original investigators, truth-fearing and truth-loyal men, men that cannot be frightened, fatigued or discouraged, they will have students like themselves. Students like-minded will come from the ends of the earth. The investigators make the university as the teachers make the college. It is not necessary that many departments be developed to make the university real. It is said that Agassiz in 1850 was himself the sole university in America. The presence of Agassiz and Gray, Lowell and Longfellow, Holmes and Goodwin, Felton and Norton, meant a university atmosphere; Silliman and Dana meant the University of Yale. Such men are as rare as they are choice. No university faculty was ever made up wholly of university men, and no one ever had too many of them.

From such men as these the American scholar is descended. The growth of American science is his work, and of this growth he is in turn a product. That he may never grow less we hope and pray. And this with a certainty that our prayers will meet their answer. Our faith is shown by our works. With the best of these let us place our new temple dedicated to the holy life of action, to the worship of the God of things as they are, our new Palmer Hall of Colorado College.

THE VALUE OF SCIENTIFIC TRAINING.

By President Charles R. Van Hise.
University of Wisconsin.

On the occasion of opening this beautiful and spacious hall to science at Colorado College I have felt that no theme could be more appropriate than the value of scientific training. In considering this subject I shall speak of the practical value, the intellectual development, and the importance to the nation of scientific training.

Colorado is one of the great agricultural states of the Union. The value of science to the farmer and ranchman cannot be overestimated. A knowledge of the elements of physics, chemistry, and biology and their applications to agriculture are essential to the enlightened farmer. For instance, to know the sources of combined nitrogen so necessary to plants is fundamental to wise farming. How combined nitrogen can be gotten into and retained in the soil is an ever-present problem. If the farmer understands that the legumes and the bacteria co-operate to abstract the free nitrogen from the air and store it in a combined form in the plants, his attempts to recuperate the soil in nitrogenous compounds will be carried on in an intelligent manner. In Colorado and other Western States, another of the great agricultural problems is to prevent the alkalies from accumulating in the irrigated lands. To avoid this demands a thorough knowledge of physics as applied to the soils. Lack of this knowledge has already ruined extensive tracts of once highly fertile lands in the West. Notwithstanding numerous problems similar to those mentioned, it is sometimes said that the knowledge which the farmer needs can be acquired by rule of thumb; that there is no necessity for a comprehension of the principles upon which his action is based. Nothing can be more erroneous and shortsighted than such teaching. A farmer lacking scientific training is a human machine, which mechanically follows established practice for the money which results from his uninteresting toil; and even financial success is less likely to come to him than to the farmer who has a scientific knowledge of his profession. And what a difference in the intellectual life of the two men! The work of the unlearned farmer is wearisome physical exertion. Though he grow rich he is a farm laborer. How different from the possibilities of his occupation! How far from the ideal! He might, as he turns the soil, appreciate the manner in which this benefits his crops. He might see in his growing plants the wonderful forms and transformations of life in all its strange beauties and manifestations. He might see that even the beauty of the flowers is for their use; that the plants are not independent of the animals; that the insects, the despised earth-worms, and even the myriads of bacteria in the soil are necessary co-workers in the fruitfulness of his fields. Ever in his work all the beauties and complexities of orderly nature are before him to stimulate his observation and reflection. The scientific farmer has the knowledge which will at once give him financial success and transform his occupation from one of drudgery to one of pleasure. When farmers are scientifically trained the occupation will no longer be regarded as inferior. Is it too much to hope that in the future the applied science of farming will become recognized as a broad and enlightening vocation—as one of the learned professions?

The importance of scientific training in engineering callings is manifest to all. Colorado is a State demanding the services of many technically trained men. Civil, mechanical, electrical, metallurgical, and mining engineers swarm upon and within the hills of Colorado. In this state ditches and flumes are rarely out of one's sight. Railroads, the great transporting agents which have revolutionized commerce, follow the meandering streams, burrow through the hills and mountains, and here breast even the Front Range of Colorado, winding outward around spurs and swinging inward across ravines and gulches. In many districts the shafts and drifts and rooms of the mines honeycomb the hills. The ore and coal abstracted from the earth meet in the metallurgical plants, and there the metal is separated. All this work is done under the direction of engineers, every one of whom has had more or less of scientific training: and the better, more thorough-going and far-reaching the training, the higher priced but the more economical the man to his employer. What mining engineer is too deeply grounded in science? He who is to develop an ore deposit must fully appreciate the complex problem before him if he does his work in an enlightened manner. The principles of physics and chemistry and mineralogy and geology he must know broadly and deeply, if he is to see that even the apparently lawless ore deposits conform to the universal orderliness of nature. The man who grasps this order, who understands what to expect from what he sees, must have had a long and rigorous training in a wide range of the sciences.

Still another direction in which scientific training is demanded is in the household. It is scarcely a quarter of a century since the importance of scientific training was recognized by the farmer. Twenty-five years hence it will be regarded as equally essential to the successful head of a household. The selection and preparation of foods demand broad scientific knowledge. The time will come when the cook will no longer blindly follow the receipts of a book or put together in a haphazard way the various ingredients of a dish. The scientific use of foods has become so important that scientists like Atwater have chosen as their life work the consideration of the nutritive value of foods and the best method of securing their full efficiency. Atkinson says that America has the greatest abundance of the best food materials and the poorest foods of any civilized nation. Until the head of a home has a working knowledge of the principles of chemistry and understands their applications to foods she cannot direct the work of a house in the best possible manner. Household sanitation should be understood by every mistress of a home. We now know that physical health is an essential condition of effective work of any kind. Even in the larger and more ostentatious houses the occupants are poisoned by carbon monoxide from the furnace, and are subject to contagion from defective plumbing. Indeed, it is not too much to say that many pretentious residences are less healthful than the two-roomed cabins of the poor, heated with stoves and innocent of plumbing.

When the mistresses of our homes shall understand the principles upon which the selection and preparation of food should be based, when they understand household sanitation, a great stride will have been made in the development of the race. But the advantages of scientific training to the mistress of a house are not limited to the physical welfare of the occupants. Often the women complain of the wearisome repetition of their work. It degenerates into drudgery because they have no adequate knowledge upon which to conduct their work in a scientific fashion. They can only follow the dull routine of traditional rules. When the mistress of the house has the knowledge which will give her opportunity for effective exercise of her mind in the systematic and scientific management of her house, interest will be added to her duties and the occupation dignified, as agriculture has become dignified by the application of science. All occupations become dignified as soon as the interest passes from routine to comprehending oversight.

But the practical value of scientific training is not restricted to those who are handling the materials of nature. It is of almost equal importance in the professions which in the past were regarded as the only learned professions, but which now can no longer claim this arrogant title—the law, medicine, and the ministry.

From time immemorial these professions have been regarded as having no necessary relations with science. But no longer is the lawyer well equipped unless he is sufficiently grounded in science to be able to apply its principles for his client's interest in a particular case. In earlier times the great majority of law cases concerned commercial transactions, transfers of real property, and the personal relations of men. The development of vast manufacturing plants, the rise of the colossal transporting corporations with their franchises, and the amazing extension of mining in the nineteenth century have made new demands upon the lawyer. Today he is called upon for special knowledge in physics, tomorrow in chemistry, and the next day in geology. The mining lawyer who is to be successful must know not only the law of the apex but he must have a sufficient knowledge of all the basal sciences so that he can readily comprehend the manner in which the ores were deposited. Of the general lawyer is in turn required knowledge in all the sciences.

But the question may be asked, is it expected that the well-trained lawyer will have the detailed scientific information which will enable him to grapple with all of the problems of science which may come before him in his professional career? This cannot be expected; but what the well-equipped must know is the fundamental principles of the basal sciences so that in consultation with a scientific specialist he is able to understand the bearings of the questions involved. Without such knowledge he is not able to take full advantage of the advice of a specialist. The day has already gone when the lawyer can afford to be without knowledge of science, as many a bachelor of law will learn to his cost during the next score of years. The time will come, and that soon, when it will be an axiom that science must be the backbone of the preliminary training of a lawyer.

It is everywhere agreed that science is an essential part of the training of one who expects to practice medicine. And of equal importance to a physician with a knowledge of science is the peculiar intellectual spirit which scientific training gives. To the practitioner who has no knowledge of physics, chemistry, and biology, medicine is a mere empirical makeshift. Unhappily, so careless and so backward are we in our laws concerning the practice of medicine that we often place ourselves at the mercy of inadequately trained men. Upon the training of the lawyer may depend the protection of our property, but upon the physician our lives are dependent. In a given case a life may not be of great importance to the nation or even to the community, but almost without exception a human life is of profound importance to the friends and family. If we would protect ourselves, our attention should be directed to seeing that our laws are so framed and so enforced that no one shall practice medicine until he shall have had a most thorough-going scientific and medical training.

It is plain that the minister, as well as the lawyer and physician, cannot afford to neglect science. Ignoring for the present the value of the scientific spirit in dealing with theological and religious questions, it seems to me that one whose chief work is to teach by word of mouth is very deficient in his equipment if cut off from the scientific contributions of the nineteenth century, the most remarkable and the most revolutionary in the history of mankind. A minister lacking training in science frequently picks up from the newspapers and magazines random and loose statements concerning science which in a still more attenuated and misleading form he gives to his congregation as scientific knowledge. Too often one is obliged to listen to the pseudo-scientific nonsense which the minister pours upon the people, not even appreciating his own ignorance in reference to the elementary principles of science nor having any comprehension of the scientific spirit which has taken possession of those who are now moving the world.

And if we examined we would find other occupations which persons with liberal educations are likely to follow have—with farming, with engineering, with housekeeping, with medicine, with the law, with the ministry—as one of their direct needs a fair understanding of the basal sciences.

The practical deduction which follows is that no person at the present day who would become liberally educated in the broadest sense can wisely omit from his course the fundamental sciences of physics, chemistry, and biology.

Physics teaches of the manner in which the many strange forms of that something we call force acts upon matter. Chemistry teaches of matter—how it is made up both in life and in death; without an understanding of it we have not the faintest insight into the constitution of any object with which we come into contact. Biology teaches of the great world of life, of which our bodies are a part and with which at all points we are in contact. A person who lacks any of these three lines of knowledge I do not hesitate to say lacks one of the elements of a broad, liberal education. The first popular magazine or newspaper which comes to his hand may contain an article which he cannot understand. He not only is not satisfactorily equipped to take a leading part in any of the professions, but he is not in a position to carry on a conversation which without pedantry may arise at any moment.

At the present day a man who is trained only in science or only in the humanities has but one hand; that hand may be strong, but the man can never control the affair before him with the power, with the nicety of a man with two hands, one of which is the rich treasures of the humanities and the other the no less rich and important treasures of science, each doing its part in harmony with corresponding fullness of results. With a fundamental knowledge of both, the scholar of the future may choose as his chief occupation the clear, cold work of science or that of literature, of history, or of economics, which will always have more followers, because of their direct human interest.

From the foregoing it will be seen that science has inestimable practical value in securing success in the more important vocations. Equally important with the practical value is the intellectual training which science study gives. And here, to my mind, is the justification of scientific training in colleges and universities for all classes of students whatever their life work may be. It may or may not be of practical importance for one to know science in business, but it is of the highest importance that he shall have the peculiar intellectual training which science gives.

The first of the powers of the mind trained by science is that of observation. That such studies as botany, zoology, mineralogy, and geology have a peculiar and unequalled value in this direction is conceded by all; and this is an important concession, for but few of our powers are more valuable than this. The difference between two men, one of whom is a quick, accurate observer and one whose faculty of observation is dormant, is much like the difference between a man whose eyes are sound and one who is blind. It is not enough to have eyes. Accompanying eyes there must be the capacity to perceive, else they are comparatively useless.

How wonderful does the crystal look to one who understands the strange interior arrangement of its molecules by which it analyzes the subtle light. He discriminates crystals of many kinds, each with its own peculiar complicated variety of forms, with certain limits of variation beyond which it never goes.

With what interest does the student who has studied botany look upon the plants about him! This subject is a revelation to one who for the first time opens its book of life. What student of this science does not remember the thrill of delight with which he viewed the plants of the earth after having begun to perceive the significance of their various parts—when he for the first time really saw them?

Zoology gives the same insight into animal life that botany does into plant life. How differently do the humbler animals look to the youth who knows of their marvelous development from the embryo—who comprehends the likenesses which bind them to the higher forms of life.

In the inorganic and organic kingdoms alike after one has learned something of their wonders he perceives innumerable things that have always been mirrored upon the retina of his eye but which his brain has never before noted or comprehended. One may be a passenger on a train at intervals throughout his life and never have any idea of the number of driving wheels of a locomotive, much less have any appreciation of its multitude of other parts. But the engineer sees at a glance the innumerable parts of this complex machine and understands how each is adapted to the purpose of the whole. Just so the person trained in science sees deeply into the wondrous world in which we live.

While it is freely admitted that science is valuable in training observation, I think it is the impression with many that it gives little farther disciplinary training. Voicing this sentiment, I heard the remark not long since from a classical graduate, "Oh, yes, I suppose science does teach observation; but that is about all it does, is it not?"

Perhaps the best way to obtain a clear idea of some of the lines of culture given by science is to follow the work of a student in some one science. It makes but little difference which is selected for the illustration, so alike are they all in their essential effects upon the mind of the student. We shall take the work of a student in chemistry, a branch of science which is to be taught in Palmer Hall, and the elementary facts and general methods of which are widely known. For convenience the work in this science may be divided into three stages, illy defined and overlapping, yet, for our purpose, sufficiently distinct. In the first stage, in the lecture room and laboratory, the student familiarizes himself with the elements, some of their simpler compounds, and the principles of their combinations. In the second stage, the student is in the qualitative and quantitative laboratories. In the first of these he is given compounds the composition of which he does not know, and is required to determine the elements which compose them. In the quantitative laboratory he not only determines the elements in the compounds but the percentage of each of these elements. In the third and last stage he becomes an original investigator.

In the first stage of the work, that in which the elementary facts and principles of chemistry are mastered, the kind of power needed and the intellectual training given are the same as in other lines of study. But when the student gets into the second and third stages, the peculiar value of scientific training appears, and into the effect of this work upon the mind we would inquire.

The student is passing through his course in qualitative and quantitative analysis. He is required to determine the elemental composition and percentages of the elements in substances placed in his hands, and he thus becomes a truth seeker. Even if at first his object is but to make a report to his instructor of the correct composition of the body given him to analyze; even if his own mind does not formulate the fact that it is searching for the truth, this fact shapes his work; for, state it as you will, when reduced to its underlying idea it is but the truth as to the composition of the substance that he is seeking. The student may probably never think of himself in this light; for rarely do men, even when students, formulate the underlying abstract principles to which their concrete actions correspond.

The analyst, then, is not preparing a plausible argument upon one side of a question, with the thought only to show intellectual acumen, as debate too often is. He is not simply going through a course of mental gymnastics, as some studies are to no small degree. True, as we shall see, he is being most actively disciplined in many of his most important faculties, but above all and more important than all else and controlling all else, he is seeking the truth. In his search for truth his success in this stage of his work is constantly tested. If he does not find the truth at his first attempt, the work must be repeated until a correct knowledge of the facts is obtained. The student continues this work through the months and into the years. His constant association with and compelled respect for the great law of truth cannot but produce an indelible impression upon his mind. He sees as he never saw before that this law pervades all matter. He learns practically, in actual contact with matter, that with absolute reliance he may depend upon nature to repeat the same phenomena under the same conditions. With patience he continues his work, following with respectful feet—if a true love of science has yet germinated in him—the road pointed out by the guide-board of truth.

I do not say that such training necessarily makes a man truthful in the moral world. I cannot assert that every good scientist is an honest man. But I do believe that the whole tendency of science training is in this direction. All instructors in science recognize the connection, for they carry over to science, to express excellence, words which are used in ethics. It is said in reference to a student that he is honest with his facts, of an observer that he has good morals. One who has any success in science must at the very beginning learn this fundamental idea of truthfulness in dealing with his facts. I suppose it is possible that one may possess what Carlyle calls veracity and yet not be truthful, but veracity—capacity to look at facts as they are—logically leads to truthfulness in morals; for he who sees things with insight at least sees that truth serves his turn in dealing with men better than falsehood, or, to use the old maxim, that honesty is the best policy. And no form of study is so well adapted to cultivate the faculty of truthfulness in the world of matter as science study, handling the materials of the world under the law of truth.

In this search after truth the most important disciplinary training is also gained. At once the student's accuracy, patience, perseverance and judgment are cultivated. Who knows better the meaning of accuracy than he who uses a sensitive balance, who deals with quantities so small that the difference of weight of a fraction of a hair or the loss of a drop of his solutions will invalidate his conclusions? Who understands the meaning of patience better than he who begins a work with a compound which will not yield results until after weeks or it may be months of persistent work, all of which may be rendered worthless at any moment by a careless touch, a temperature allowed to become too high, the fracture of a delicate vessel. Constant watchfulness, carefulness, nicety of manipulation, infinite patience, rigid truthfulness in operation and observation are needed from beginning to end. If correct conclusions are not reached the first time, as often they are not, the laborious processes must be repeated until persistence is rewarded with success. And in this work the student has no blind rules which are to serve as his guide. At every step an unexpected reaction is liable to occur, and this reaction must be understood before the difficulty can be overcome. He has before him throughout the process many complicated, interlocking and involved facts from which he must draw correct conclusions or lead himself to wrong actions or results which will soon become evident, and the work must be repeated to this point and the correct conclusion drawn. In short, the problems constantly before his judgment are as similar as possible to the problems which will appeal to his judgment in active life, the correct solution of which he must make if he would there succeed, just as he must now make correct judgments in the laboratory if he would become a successful chemist. Can one imagine training which is more effective in making *a man* than this? In it, his guiding principle a search for absolute truth; in this search a most rigid and prolonged cultivation of the virtues needed in his life struggle—accuracy, perseverance, patience, judgment.

In the last stage of scientific training a man becomes an original investigator. The faculties here needed and the training derived are in the line of those required in the second stage of his study. Success here is proof that the qualities which have been described as necessary to and produced by scientific work have been well developed, that the lessons of the scientific method have been mastered. The investigator has at some one point reached the border of the world of knowledge. He has gone over all the steps of his predecessors in this direction; all their knowledge is his. In his previous work the links of his chain have been fastened to other links upon either side by those who have traveled the road before him, and now he would himself add a link to the chain. If he would succeed, all preconceived ideas he must be ready to instantly surrender; all prejudice he must dismiss. He must follow with trained eye the dim figure of truth scarcely visible to him in the misty darkness of the outer world of knowledge; to any who have not step by step followed the way up to this point, totally invisible.

To the height of becoming an original investigator the graduate student must rise. The work he does may not be of great value, although often important scientific discoveries have been made by graduates and occasionally even by undergraduates. When a student does become a master of all known facts and principles along one narrow line; when he does see so deeply the relations of things that he is able to add something, however minute, to the great store of the world's knowledge, he will have gained no small advantage. It is a great thing for a man to have mastered all the facts and principles of a single small branch of a subject. The accomplishment of this mastery will give him new ideas of methodical, thorough and complete work. He who has been thus methodical, thorough, and complete at one point will carry these qualities into his further work.

And one who becomes a great investigator must combine with these qualities constructive scientific imagination. He must, from a knowledge of the facts and principles of his science, appreciate where the line of discovery lies. It is too often thought that scientific discoveries are accidental. But with rare exception a scientific discovery is the result of a deep insight into the laws of nature and the application of reasoning power of the highest quality to the facts before him. This is nowhere better illustrated than by recent discoveries in chemistry; for instance, that of argon by Ramsey and Rayleigh and that of radium by the Curies. In the latter case the discovery followed the quick perception that the radioactive property detected to an unusual degree in certain refuse material meant that in this substance some unknown compound existed which possessed this property to a higher degree than any known element. And most remarkable of all, it was the use of this very property as a guide throughout the long and tedious search, beyond the patience of any but a scientific enthusiast, which led to success in the separation of the almost infinitesimal bit of radium from the gangue within which it was hidden. And the radium separated, the total quantity of which within the possession of all the scientists of the world is but the fraction of an ounce, although known only five years, has already given marvelous advancement to our knowledge of matter. Radium promises to be one of the most useful tools yet discovered in developing ideas upon one of the ultimate subjects of scientific inquiry, the constitution of matter.

One need but call the names of the men who have attained a high place in science to have it recognized that these men had minds of the highest order, of the sanest quality, that they possessed common sense which rose to the point of genius. Will anyone question these qualities of mind in Benjamin Franklin or Charles Darwin or any of those of first rank in the roll of science?

And what pleasure more pure, what element in humanity more divine than the impelling necessity to wear out the life in seeing deeper than any man has seen before into the order of the universe? This is the very essence of the spirit of the scientist. Is it not a great thing to have lived in the nineteenth and twentieth centuries, when man for the first time has obeyed the biblical injunction to take possession of the world, when man for the first time, instead of being mastered by, is becoming master of force and matter and life? And is it not a great thing to have taken some part in the conquest? This is the dream of the scientist. And the end is not yet. Greater things remain to do than have been accomplished. I confidently predict that among those who are now at work trying to get a deeper insight into matter, into ether, into gravitation, into life, among those who are trying to catch the larger meaning of the sequence in the orderly procession of the universe in which "one can catch no glimpse of a beginning, in which he can see no sign of an end," a future generation will find some great benefactor of mankind.

Now that in general terms the qualities of the mind developed by science and the work of the scientist have been considered, it remains to speak of the working of such minds in actual contact with the thoughts and affairs of the world.

From what has gone before it is plain that training in science tends to restrain men from drawing narrow, illy based conclusions. A man who is trained in the scientific method and is somewhat familiar with the facts of nature handles the material and phenomena of the world with which he comes into contact more wisely than one not trained in science.

But the advantages of the rise of science do not stop with material things. The power which science has had upon the thought of the world is shown nowhere more than in the new methods of studying language, history, economics, political science, sociology, and philosophy. These branches have had a growth in the past few decades unparalleled by that of any other period of the world's history. This growth has followed the mighty strides of science. In these branches we hear almost as much of the scientific method as in the realm in which the term arose, and within which its significance can best be appreciated. The rapid advance in sociology, philosophy, and religion, is the result of the application of the scientific method to these subjects. It is quite within the bounds of well established and admitted fact to state that the recent marvelous progress in the humanities would not have been possible had science not been developed as a method of training.

A point to be considered in this connection is the popular assumption that science studies are exceedingly difficult. This in fact is usually the excuse given for ignorance of science by many men educated in other lines. Real insight into the fundamental laws of any subject is difficult to acquire. If science appears difficult, it is because its terms are accurate and no loose work will suffice. Its difficulties are those of approximate exactness. A subject is really difficult in proportion to the number and complexity of the terms with which it has to deal. Judged by these criteria mathematics is the simplest of all branches. Natural science is more difficult, and social science is the most difficult of all. Popular ideas exactly reverse this order. The difference between mathematics and social science is, that in one case we can test the accuracy of the result, whereas frequently in the other case no one can disprove the statement made or test the truth of it. If a lecture on a social topic has a sonorous and plausible sound, it is usually accepted at its face value without much reference to its real merit.

Mathematics, the branch of knowledge which, if any, gives absolute results, is severely limited in its scope. Its very exactness makes it unable to handle complicated problems. With the most refined of its highest forms of analysis, it has not yet solved the problem of three bodies moving under the influence of gravity. In natural science the terms are more numerous and less exact, and the results, while reasonably certain, have not the complete exactness of mathematics. We say without thought that we are confessing lack of capacity, that we cannot comprehend science; yet most of us feel that we *know* the solution to the multifarious social problems to which perhaps we have really never given any serious thought.

In economic, social, and moral questions men are continually reasoning erroneously. They continually mistake effect for cause, and cause for effect. They constantly grasp a single fact or aspect of a social question and leap to conclusions which have either no connection or a very partial one with the cause assigned. Reasoning of this sort we hear daily applied to the burning social and economic questions which are pressing upon us for successful solution. Doubtless a part of the silly and harmful talk upon such questions is dishonest and for a partisan or temporary advantage, but it is a lamentable fact that the great mass of it comes from defective knowledge and incapacity to think straight. Now, if ever, in the world's history we need men to grapple great social and moral questions and instruct the masses wisely; men who carry the scientific method into their discussions.

In a social problem how very numerous are the factors with which we have to deal. Here are the uncertain faculties and passions of human beings, a vast number of persons of different nationalities, of different training, of different hereditary powers. The terms of the problem are indefinite; the elements are unnumbered; these elements have uncertain values; and yet almost every person has a positive opinion as to the correct solution of current social problems.

As a matter of fact no mind in existence can exactly measure or even number the factors involved in a social problem, much less certainly see the complete answer. It is not supposed that this will prevent anyone from having opinions upon current social questions. After the fullest consideration of them of which we are capable, we can do no other than to make the best guess we can and go ahead. The chance that the guess will be *all* right is indefinitely small, but some part of it may be found to be right, and in the slow evolution of mankind, by means of empirical trial with resultant unmeasured and unmeasurable suffering, that part of the guess will be adopted and the world will make a step forward. But certainly our opinions on social subjects, when we confess our inability to fully comprehend the simplest operations in those lines within which we have exact knowledge, ought to be held doubtfully, with eyes stretched to the utmost for new light, in order that by prompt revision of social habits some moiety of the pain of our never-ceasing regeneration may be escaped.

Since it is manifest that we must deal with social problems, which are far more difficult than science problems, a lack of knowledge of science cannot be excused on account of its difficulty. To be *master* of any subject is superlatively difficult, but to gain a knowledge of the elements of science is an indefinitely easier task than to get the training which gives one a right to an opinion on a social topic.

We look well to our political institutions, and he is regarded as a benefactor of mankind who betters them at an important point. But while we are so careful as to the nature of the relations which shall obtain between man and man in future generations, we are using the bread and butter of our descendants with no thought that our waste means their starvation. It took the building of the world to produce our natural resources, and when the stores of nature are used, they are gone forever. The material progress of the few past decades has revolutionized the habits of mankind. Already a large part are drawing liberally upon the underground supplies of nature, and within a few generations all will be as rapidly drawing upon them. A hundred years ago our mineral wealth was practically untouched, but as a result of the introduction and wide use of steam for the production of power, not only coal, the source of the greater part of energy utilized, but other minerals are being taken from their recesses within the earth with a rapidity never before approached, and this drain is going on at an accelerating ratio. It has been repeatedly calculated that at the present rate of consumption the known supplies of coal will be exhausted at the latest within a few thousands of years. Other supplies will doubtless be discovered, but the amount found will perhaps no more than compensate for the increased rapidity of use, so that so far as we can now see, within a short time in the future, compared with the many tens of thousands of years of the history of the human race, our supplies of coal and many of our metals will approach exhaustion.

But a still more striking but less momentous extravagance is the destruction of our forests. These at the present rate of devastation cannot last more than one or two generations, and yet each year by carelessness and lack of sufficient protection many square miles of forest are burned. Almost constantly during the late summer months in Colorado and the other states of the West the smoke of the consuming flame obscures the mountain peaks.

Another piece of recklessness consists in clearing the soil of its protecting vegetation and then allowing the rain, which before made it green with verdure, to sweep it into the sea. To create the soil of our rich lands occupied millions of years. All through the South, and at many places in the North and West gullies have been allowed to cut their way into the fertile farms. A ravine once formed reaches out its fingers to the right and the left, eagerly snatching the light loam and carrying it to the river. The area tributary to the ramifying system of ravines becomes ever larger. The social upheavals of the Civil War led to unusual neglect in the South, so that the process in many districts obtained a firm foothold. Since the Civil War wide stretches of land in many states have been made a waste. According to McGee, at least one-tenth of the State of Mississippi has been converted into veritable Bad Lands, the counterpart of the region of that name in the Dakotas. The system of ravines now well established continues its work with accelerating speed, and every additional mile thus added makes the stoppage of the process more difficult.

Our own country is not alone in having to contend with the problem of saving the soil from the sea. It is one common to many countries. We are alone among civilized nations only in allowing the process to go on with little attention and with small attempt to arrest it.

Is it then maintained that we shall not draw upon the stores of coal and ores and timber and soil? Not so, but we should draw upon them as carefully as we do upon our bank accounts. By our present methods of coal consumption we get but a fraction of its efficiency. Methods are known by which two or three times this efficiency may be obtained, yet we continue year after year to undo in a wasteful way the many ages of labor of Sun and Earth.

We, the American nation, priding ourselves upon our cleverness and posing as the leaders of the world in all material progress, will be regarded by our descendants as the most profligate of the people of all times. At once we are burning two or three times as much coal as necessary; we are setting our forests on fire; we are dumping our soil into the sea. Did the world ever before witness such stupendous folly? The complaints which our successors will make against this generation because of the imperfections of its political institutions and the consequent evils to which they are heirs will be trivial compared to the blame, I had almost said curses, which shall fall upon us because of our material wastefulness. While we shall be recognized as the people which first began to know the meaning of the phrase "having dominion over the earth," we shall also be charged with being the most wantonly extravagant people of all time.

If the wise application of science is at the root of progress in life, both physical and moral; if an understanding of its bearing upon the future is imperative in order that we may deal justly with posterity: it is necessary that the people gain such a knowledge of science as will enable them to appreciate their duties to the world in which they live, being more than moles that with rudimentary eyes conceive the universe as burrows in the ground within which they may gain sustenance. In this work a great duty devolves upon institutions of learning and upon scientific men. The scientific truths of importance must be disseminated throughout the nation and the world, so that an enlightened public opinion may demand of lawmakers such regulations as will preserve abundant material resources for the coming generations. For this dissemination of science are demanded the best faculties of the foremost men of science and the best endeavors of the schools.

But what part is Colorado to play in the applications of science to the arts of living? What part is she to assign science in the intellectual life of her people? What part is she to play in conserving the resources of the nation? And finally, what part is she to take in research, in the advancement of knowledge; in the discovery of new principles which will further ameliorate the condition of mankind and give a deeper insight into the order of the universe?

Certain it is that the opportunities in Colorado for this work are second to no region of the world. Happily located in the central part of the temperate zone, between the benumbing cold of the North and the enervating heat of the South, with broad and stimulating plains, with beautiful valleys, with wide parks of entrancing beauty, with profound and awe-inspiring canyons, with mountains of sublime proportions, no State on earth is more fortunately situated as to climate and scenery; no people more happy in their environment.

The great inequalities of altitude, the alternation of smooth and rugged land, the varying rainfall, give the State a marvelous range of life, from dense forests and abundant animals to the sparse and strange plants and animals of the desert. This range of conditions gives an equally great range in cultivated products. To the splendid agricultural resources must be added the wonderful metal mines, from iron to gold. The stories of the discovery and development of Leadville and Cripple Creek have stirred the world. To the metal mines must be added the extensive coal fields which furnish the energy by which man handles the other material resources of the State. In consequence of the unexcelled range of resources, the industries of Colorado are as varied as the scenery. The demands for applied science are co-extensive with the range of industries.

And what of the people? For upon them depends the wise or unwise use of their opportunities. The early settlers of Colorado were largely selected from the once selected people of the Middle West and the Pacific coast, and thus were twice selected. An overwhelming majority of the people are of Teutonic stock, and of these the greater number are Anglo-Saxons. These frontier people and their sons and daughters are the dominant race of Colorado. As yet they have largely occupied themselves with roughly, sometimes almost savagely, harvesting the rich natural resources of the State.

But there are signs that the people of Colorado are no longer satisfied with mere material achievement. Those who intend giving their attention to developing the soil, the timber, the mines, will demand for themselves a scientific training so that they may wisely serve the State and conserve its resources, so that they may enjoy continuous intellectual pleasure in their work. And here and there among the young men of the State a scholar will rise, whose most elemental thought is to see deeper into the order of the universe. Search well for this spirit and give him unbounded opportunity; for he is a benefactor not only of the State but of the entire earth; for a new truth, a new principle, is not the property of any state but instantly belongs to the world. The final and supreme test of the height of civilization of a state is its output of creative men—not in science alone, but in art, in literature, in ethics, and in religion.

Can it be doubted that Colorado, with such a rich and varied soil, with unsurpassed mineral resources, with such a hardy people, belonging to the most fruitful of races, in the midst of inspiring surroundings, shall give to the world scientists, artists, poets, and philosophers? For my part, I look to this western region with unlimited hope; and no State in its vast expanse can be looked toward more trustfully than Colorado.

Palmer Hall, and other buildings of like character, are evidence of a new epoch in this State. It is a matter of profound congratulation not only to the State of Colorado, but to the nation, that the president and generous supporters of Colorado College have so clearly seen the great place which scientific training and research are to play in the future. It is evidence that Colorado College is to do its part in the great work of the application of science to life, in the development and extension of the scientific spirit, and in the advancement of knowledge.

Dedication Sermon.

By Professor Edward C. Moore, Ph. D.,
Harvard University.

On the front of your new building are inscribed these words, which I have chosen for my text:—"Ye shall know the truth, and the truth shall make you free."—St. John 8:32.

There is no word more unceasingly upon the lips of the men of our generation than the word liberty. There is nothing of which men are so zealous, there is nothing at the abridgment or even at the threatening of which men will so easily take fire. And yet I think that it is the commonest experience, whether of the boy who has just gone out from school, or of states and nations, which have entered into the inheritance of all that for which the ages struggled, there is no commoner experience than this; that a brief use of liberty brings us upon a sense of limitations that we had not dreamed, and makes us, when we are sober and thoughtful, to doubt a little whether we quite know what freedom means.

We are so accustomed to the use of phrases about our determining the truth. We say so easily, I hold this to be the truth. We are so familiar with the fact that some-one else holds something else to be the truth. Old truth is outworn and new not altogether apprehended. And we are often in the mood which asks in all intonations, solemn, flippant, or bewildered, Pilate's question, "What is Truth?"

And what has truth to do with liberty? Truth is something talked of in our colleges, which seems to give pleasure to the class of people who get pleasure out of knowing things. And truth about stones may help one with his mining, about crops, with his farms. In one sense, truth may be a new tool of trade, a help to handcraft, an aid to all men in their struggle to get livelihood. But what has truth to do with liberty?

The ideas are so wide and complex, definition is not easy. The thing has to be looked at from many different points of view. And yet it has seemed to me that there would be such gain and such power in it, if we could come to understand these phrases that I have dared to try to help you to understand.

What is liberty? We approach things in the rule from the outside. We are apt to think liberty as existing first of all in the absence of external hindrance or restraint. The stone far up the mountain side, loosened by the frost in spring, is free to fall. The sapling, bent to earth, set free, springs back to its erectness. The bird, escaping from his cage, flies joyfully away to his old life. The beast breaks his bars and seeks the wilderness. Prisoners and slaves are held by chains or fear from doing what they will. The order of society in some lands sets sharp limitations to the possibilities of life to men born in certain ranks. The necessity of daily work, viewed as it is by many men, is a mere outward and most tyrannous necessity, abridges very sharply a man's liberty to do always as he will.

But surely with what we have said we have but scratched the shell of the idea. The stone is free, but free to do what? Free only to fall, and why? Because the same gravity, which by the resistance of the earth held it in place, now that resistance is removed, puts it and keeps it in motion. Why does not water flow up hill? Why does not the sapling bend more instead of tending to unbend? Why does not the bird fly into the house; why does not the lion eat straw and graze about the streets? Well, simply because, in the immortal words of Dr. Watts, "It's not nature to." These things are free, and yet all are free plainly to do only certain definite things. There is a limit to freedom set in the nature of things themselves, and freedom for all these things plainly consists in the unhindered doing of that which is their nature to do. There evidently is a second element which comes into the conception of freedom, an internal limitation in the nature of the thing, which is infinitely more significant than all the external limitations which you may put about it.

Now when we come to speak of human liberty, the case is still more complicated. A man is obviously governed no longer by a mere external force like a stone, nor yet by an instinct like a beast. He is plainly free to act, if he sees fit, in ways which are not in accordance with his nature. He often feels himself most free just when he does these things. And then he makes the discovery that, after all, he is bound inexorably to the consequences of his conduct. A man is perfectly free to debauch himself, to degrade himself below the level of a beast, perfectly free to imagine that exactly in doing such things he is satisfactorily exerting his freedom from all forms of restraint, social, moral, religious. But in the reckoning which nature makes with him, in disease, suffering, not to speak of consequences of another kind, loss of repute, public regard, ruin of home and business, he may some day come to reflect that what he has really done, is to destroy his liberty and that not only for those unnatural things, but equally for the natural and right things which he might have done.

And still we are only on the outside of the matter, if we have forgotten one thing more. The unhappy consequences we have been speaking of are all outside of man's own character. Whereas you are my witness that the worst consequences of a man's abuse of his freedom are always in the character of the man himself, the degrading effect upon his own nature. The last consequence of being a liar is not only that men do not believe you when you do tell the truth, but that you yourself are becoming so natural a liar that you do not always know yourself when you tell the truth. The last consequence of being a fraudulent man is not that men will not trust him to do honest business, but that he himself has lost the sense of what honest business is.

I have simply shown that every such deed against nature, in the nature of it, draws after it consequences, whose direct effect is to cage up the man from without, and bring him into bondage to himself within—that is, to deprive of liberty a man who has shown himself in any way unfit to use his liberty.

A man may say that it is natural for him to do these things. Yes, but the misery and disadvantages, the bondage, the being out of harmony with one's fellows and one's self shows that they are not natural, they are not really human, they are below the human. There is part, and that the best part of human nature which in them all has not been reckoned with, has not come into play.

We are absolutely on the outside of the matter, so long as law, the law of physical nature, the laws of political economy, the laws of the State of Colorado, or the laws of the immortal God, are conceived by us as pure enactment. That is the thing which it seems to be hard to make men see, and yet there will be no understanding of liberty until they do see it. This is the evil which grows up with the sense which we have in democratic countries, of making our own laws, as if all laws were on the level of some which are lobbied through the legislature. I am not talking of wrong laws. Men are sadly human. All kinds of things affect legislation. There have been terrific blunders and great wrongs. And if laws are wrong, away with them. But the point I make is this, that if the law is right, be it dictum of science or dictum from Sinai, the enactment did not make it right, and the overthrow of the enactment does not unmake its right. Laws of nature do not become such when we first discover them. They are what they are. But we then become fully men when we discover those laws and act in accordance with them. The right was right before there were any men, and at least as soon as there was any God. The right is right, not because even God says so, but God says so presumably because it is right. Truth, moral, political, practical, is not fiat, but is grained in the very fibre of the universe, the whole nature of things reflecting the nature of God who is truth, and only the truth is God. And if you overthrow the State and swear there is not any God, the great still nature of things goes its appointed course, and has us in its grasp.

And we must not suppose that all of these things of which we have been speaking work only downward. Affect only the men who fly in the face of nature and abuse their liberty. They work upward too, they have holy and beneficent effect on men who use their liberty, as not abusing it. They have this effect then, that these men's liberty grows wider every day, as before we saw it grow narrower.

You know how a man of stainless integrity, of knowledge of his business, is trusted, believed in, not only where men can watch him, but also where they cannot. And every year of such spotless life deepens trust, widens his liberty to do for himself and for others what he will. Men know that he follows the truth, and every year has been refining him and making him more clear-sighted of his truth and more sure to do the truth he knows. Every year has been throwing down the barriers without, which once hemmed him in, and freeing him from all bondage within, from any prejudice or passion. The true life leads to liberty. And all our bondages, not only our sins, but even human tyrannies and bad political economy are due simply to our getting at cross purposes with the truth. Such distinctions as physical, moral, spiritual, geological, historical or theological, truth are only fences for convenience's sake. Nature is one, and all truth is but one. Geology, history, political economy, in so far as they are known to be true, are as sacred to us as the revelation in the Bible or from Christ. And these are not sacred unless in experience they turn out to be true. All are revelations of one God in their own spheres.

The function of Christianity in this whole relation, as I see it, is not to furnish us with a sentimental substitute for studying to find out the great truth of all these things. But it is to make us more sensitive and more determined to find out our blunders, more zealous in our search to know the whole truth, and more faithful always to do all the truth we know, no matter what it costs. Any religion which does not do that for us is a superstition and a falsehood and a snare, and is unworthy of the name of religion at all, unworthy of man, unworthy of God, unworthy of him whose whole life was so simple a pursuit of and obedience to the truth, and who has left us this word: "Ye shall know the truth and the truth shall make you free."

But somehow the truth sets free only the man who obeys the truth. After all, a man is only so much active capacity, and whatever appropriates his interest, absorbs his activity, calls out his vitality, possesses for the time the man. If it possess him often enough, master him continuously enough, it alters the man. It goes to form or to change his nature and adapt his powers. It may even circumscribe his ideas, limit his desires, and extinguish certain capacities. This is true of the way in which a man becomes, say, a great musician, a true student, an ardent soldier, a good business man. The man all unconsciously while seeking to master the thing, has really become the devoted servant of it. And you may believe me that no man ever became the master of anything who was not the devoted servant of that thing. And yet, of course, this idea is all the more true in the region of the moral life and character. Always about all full-blown iniquities, there is this awful semblance of their having made victims of the people who are guilty of them. And indeed to the victims themselves, it is no mere semblance. It is awful reality. Only that over against this power of evil, which is so dreadfully obvious, there is a precisely similar power of good. This is the way in which we must explain a man's being good, that the good has got possession of him, gathered a momentum for him, he has become the servant of the good. Not that a man in a moment of opportunity and decision is always harping on his freedom to do either this or that, balancing in mind whether he will be honest, pure, or not; but rather that he turns and cries: "I am not free to be anything but honest, I have parted with my right to be anything but pure, high-minded. I am the servant of righteousness." The boy says, "I am free to practice at my music if I will and not if I will not." But that is not the road by which anybody ever became a musician. By and by when he plays it is as if his soul were not his own. This is what Socrates meant by the

Daimon of the good; and Jesus when he said, "Greater works than these shall ye do."

Freedom, you say? Yes, we have freedom. You can choose which mastery of life you will, but there is not a hand breadth of life where you do not have to reckon with the might of good or evil, working with you or against you, just according as you choose. The freedom does not consist in doing what you please, no matter what you choose to please. But freedom consists in choosing that mastery which more and more will bless your life, opens life to you, and calls out your powers and fills your life and glorifies it.

Oh, if we could only believe in this power on our behalf of the mastery of good in our lives, this accumulation of power behind us through the faithful practice of the true and good. We should not feel ourselves to be the masters of so much righteousness as we conclude to find convenient or profitable. But we should own ourselves to be the servants of what is good and true, slaves of it, bound to it, morally unable, from the heart unwilling, to be one moment unfaithful to it. Oh, the rest and peace of feeling that there is this strength supplementing and enforcing our own wills, that there is this power which enters into us through right habits, practices and pure intent, and transforms us slowly after the image of the thing which we intend, adapts our powers, confers upon us new perceptions, accumulates for us an untold momentum. Paul boldly said: "I am a slave of Jesus Christ." And I think he would have mourned with all the wealth of his rich nature over some men and women whom we know, to whom the gospel always seems to be an infringement of their liberty. The mastery of Christ presents itself to them as a sort of surrender of their own freedom, an extinction of themselves. Why, dear friends, you don't seem to know what liberty is. There is no freedom of nature or life like that which comes of a man being possessed of the power, mastered by the enthusiasm of the richest and highest life.

And now let us ask ourselves concerning truth.

The breach which was once supposed to separate the truth of science from the truth of faith has been gradually closing, or rather, it has been revealed to us as we advance, that the breach does not exist. The chasm which separated men of science from the men of religion, the distinction which made of them two hostile camps with opposing interests, has disappeared, or is fast disappearing. If there is one conviction that is fundamental to the men of our generation beyond all others, it is that of the unity of truth, of the uniformity, universality, the certainty of the laws of truth. It is that of the adaptation of man as man to the truth and of the truth to man. It is that of the privilege of discovery, of the duty of obedience unqualified to that which we discover, and of the glorification of man's life through such obedience. Nobody any longer really believes that the truth taught to men who are to be ministers or Christians is a different kind of truth from that taught to other men. If he does believe that, it is to him equivalent to the assertion that they are not taught truth at all.

The truth is not a mere matter of opinions, these or those. The truth is not what men happen, ever so ardently, to think—though God grant that we may always be found trying to think the truth. But the truth is the great world of facts of life and God outside ourselves and independent of us. Things are as they are, and a man's duty and his privilege is to find out how they are. The truth exists whether we know it and follow it or not. It is a great state of things, a supreme and unchangeable quality of things, almost we come to think of it as a great life and power of things permeating all,—the truth of things. And not only is the truth the great fact, but it has tremendous power. We can do nothing against it. We may try. We often do through mistake or in wilfulness. But it is of no use. We may launch ourselves and others upon lines of conduct which have for their end the establishment of our opinions of the truth. But whether they are true opinions, that is the final question.

We talk, for example, about determining the truth. Now we can determine our attitude with reference to the truth, we can make up our opinions as to it. But the facts do not concern themselves about our opinions. It is we who are being determined, being made the kind of men and women who obey or fight against facts, who humbly try to see them, or rashly try not to see them. We are braced and get a sense of direction in the world if we have an occasional vision of this superb strong thing, the truth, outside of us, all round about and over us, which was there before us and will be after us, and whom we can do nothing against. But to hear some people talk, you would think that the truth was some kind of delicate female apparition with unsoiled robes, who could never be expected to make her way through this rough, stupid world unless some of us took her under our kindly patronage. Poor defenseless and long-suffering thing that she is, somebody ought to do a little something for her. Flattering, all this, to us. She is so modest and unobtrusive that she would never make her way unless some one of us went noisily before her. Now far be it from me to belittle the notion of battling for the truth. Happy are they that are found fighting for her. But she goes her way, and we go some other way at our peril. It is the most short-sighted and dire of hallucinations that we can ever really triumph over the truth, that we can make a mistake or wrong, succeed. You may array the powers of earth and hell on the side of it, but you can't make it work. You may bolster a wrong system or seek to maintain a wrong policy, alleging that the foundations of the universe will be subverted if this thing is touched; you may try by way of strengthening it to get its roots around some of the foundation stones of the universe; but if it is false and wrong, the thing will have to go, even if the foundations go with it. There is no greater lesson which the history of humanity has to teach.

It is so in our attitude toward nature. It would be amusing, were it not also a little pitiful, to hear men talk about the way in which we have reduced nature to serve us. That is rather a foolish way of putting it. We have found out certain aspects of her truth, we adjust our activity according to her laws; doing so, we get the benefit of her tremendous force. But if you want to find out just how much mastery over nature we have, you want to set yourself against one of her laws. It has been so with the advance of science. Being right is always a matter of being on the side of the facts. And the facts are what they are, no matter who says that they are not.

It is so with social and economic conditions with which we are struggling. In respect of the true principles of finance, of the organization of trade, of the adjustment of relations with labor and the true use of capital, of the purpose and method of charity, we have made mistakes, and our mistakes have brought us to book.

The question is not what are the theories, but how do the theories agree with the facts. In the face of the facts, nobody can long go. And the wise do not care to try. The resort to violence of any kind, mental, moral, or physical, to find out the truth and get it done, results inevitably in some new form of error.

I draw my illustrations from all sides, that we may see that all truth is one, and the law of all approach to it is the same. There are no particular portions of it which have private ways for favorite individuals. There is no realm in which assumptions, old or new, pious or impious, count for anything.

From the sublimest question of the scientific theory of the universe or the banking of a great nation to the management of your factory or the adjustment of your home, the half-unconscious going in and out among our fellows, we can do nothing against the truth. But we can do all things with it. Nay, it will do all things for us.

It is the truth alone which makes us free, and there is no freedom save that which is by the truth.

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(*Continued on inside of back cover.*)

FIG. 1.

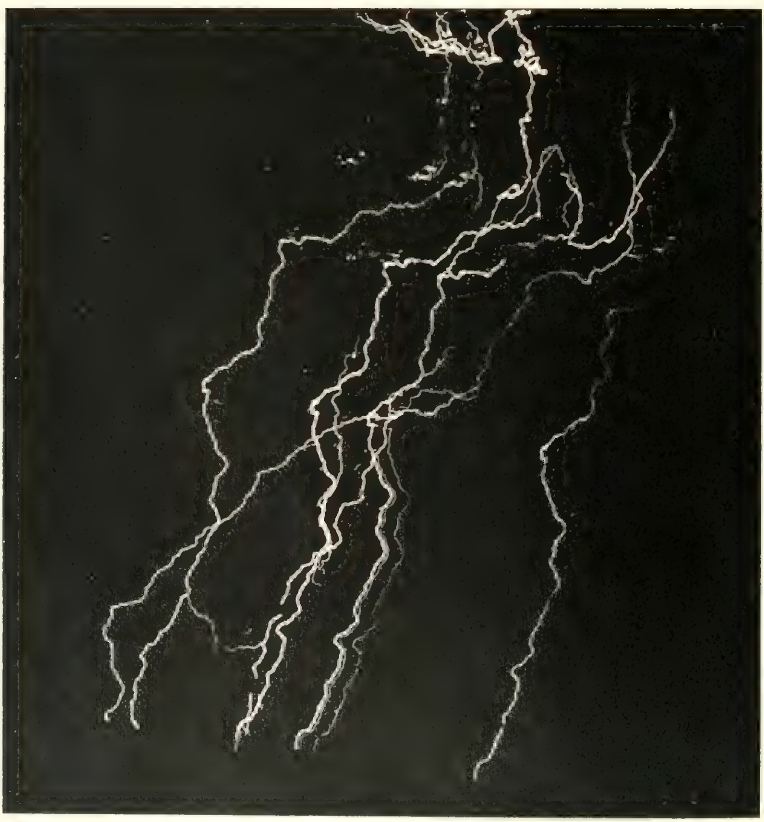

FIG. 2.

SUMMARY OF

METEOROLOGICAL OBSERVATIONS,

January to June, 1904.

By F. H. Loud, Director.

I. Description of Observatory and Instruments.

The geographical position of the observatory of Colorado College, as determined by reference to neighboring monuments of the U. S. Coast and Geodetic Survey is, latitude 38° 50′ 44″, longitude 6^h 59^m 16.5^s west of Greenwich. The elevation is about 6,040 feet above sea level.* It was built in 1894, and was the gift of Henry R. Wolcott, Esq., who also presented to the College a four-inch equatorial telescope by Kahler of Washington, D. C. In 1900 Mr. Chas. S. Blackman of Montreal, Canada, gave a sidereal clock and a transit instrument.

As early as 1878 the college became a voluntary station of the United States Weather Bureau (or rather of the Signal Service of the War Department, which at that time comprised the meteorological office), and this relation has continued ever since. In 1886-88 this college station was the central office of the State Weather Service, then a voluntary organization under the patronage of The Colorado Meteorological Association. Since the functions of the state service have been assumed by the National Bureau, the college has maintained little more than the usual equipment and service of voluntary stations, being supplied with instruments like other stations of the same order, from the central office of the State at Denver.

In November, 1903, there was received the first instrument of a new series, more extensive and valuable than the college had ever before possessed, the gift of General W. J. Palmer, a friend and trustee of the college from the time of

*See Note, page 64.

its founding, and ever foremost in benefactions to its needs. Other instruments, comprised in the same donation, have from time to time during the year been received and installed, and, in addition to these, repairs have been undertaken on an instrument long before procured for the college through the generosity of Dr. S. E. Solly, but for some years disused, a barograph of the type devised by Dr. Daniel Draper, of New York. The new instruments have been placed in the Observatory, except those portions of the wind and sunshine apparatus requiring a roof exposure, which, with the Richard thermograph, and the thermometers of the Weather Bureau type, are on the roof of Hagerman Hall.

A description of the instruments in detail follows, beginning with the most remote from the Observatory.

A thermometer shelter of the usual pattern adopted by the United States service stands at a height of 10 feet above the roof just mentioned, and 54 feet above the ground. The whirling apparatus in general use at the government stations is placed within it, and here is attached the Green thermometer read for air temperature at the tri-daily observations, as well as the wet bulb thermometer of identical construction with the former, and constituting with it the psychrometer, while beside it, in the same shelter, is placed the Richard thermograph, as well as the maximum and minimum thermometers. Although the present account is intended to be sufficiently full for the information of the general reader, and hence will contain statements in regard to the construction and use of instruments which would be quite unnecessary to the specialist, it is considered that the instruments above named, except the thermograph, are in such general use as to require no further description. Of the thermograph, it may be said that the air temperature is communicated to a thin, curved metallic cell, containing a liquid. The expansion of the latter changes the curvature of the cell, and this movement is communicated to a lever carrying a pen. The latter is thus made to trace a line, rising or falling with the temperature, upon a chart wrapped about a cylinder, which is turned by clockwork in front of the pen. Frequent comparison has given assurance that the record thus made preserves a very fair accordance with the thermometers, though the top and bottom of the daily curve usually fall short of the extreme temperatures indicated by the maximum and minimum instruments.

Eleven feet from the shelter, and rising 7 feet above it, or 17 feet above the roof, is the iron support at the top of which rests the wind vane, four feet long. At its base are attached four pairs of wires, one pair for each cardinal point of the compass; and the vane, when pointing exactly to either of these points, closes an electric circuit through one of them. When midway between two points, as e. g.: northwest, two circuits are closed, and at intermediate points either one or two as the direction of the vane may approach nearer to one or the other of these positions.

A projecting arm, a little below the wind-vane, carries the Robinson anemometer, of the usual form, consisting of four hemispherical cups attached to horizontal arms which revolve as driven by the wind, and communicate their motion to a train of clockwork below. Here another pair of wires is so attached that the circuit is closed as often as a mile of wind has passed by.

Close beside the anemometer is the electric sunshine-recorder. The essential part of this intrument is a small air-thermometer, enclosed in a vacuum jacket which is intended to render it as far as possible independent of the temperature of the surrounding air, and influenced only by the direct radiation of the sun, which is absorbed by the blackened bulb. When the air within the bulb is thus expanded, it is forced to a greater height up the thermometer tube, where it pushes in front of itself a mercury index. The latter, when sufficiently high up in the tube, closes an electric circuit. When the sun ceases to shine, the air contracts, the mercury drops, and the current is broken. Evidently the correctness of the indication given depends upon the adjustment, which must be so made, by giving a suitable inclination to the instrument, that the mercury may always reach the platinum points when the sun shines, and always fail to reach them when it is clouded. The inclination which is best adapted to this result at one season is not best at another, and in the hottest summer days no inclination has given completely correct results, the tendency in such weather being to record sunshine all the time, though the sun may be out of sight. Much more commonly, however, the error is in the opposite direction, the sunshine of the early morning, for instance, failing to record itself until the sun has reached a considerable altitude.

The wires from the wind vane, the anemometer and the sunshine recorder are laid with suitable insulation in a lead-covered cable which is enclosed within a metallic pipe, and thus the electric signals from the instruments are conveyed underground from Hagerman Hall to the Observatory. The batteries supplying the current are in the upper story of Hagerman Hall, in the room occupied by the two students who care for the instruments and take the tri-daily observations. In the same room is the Green mercurial barometer, which is read at the same hours with the other instruments at this building. Beside it has been kept the Richard barograph, which is similar to the thermograph, save that the cell containing an expansible liquid is replaced by an aneroid barometer.

At the observatory are the rain gauge, the quadruple register, the Draper barograph, and the window-shelter containing instruments for hygrometric observations.

The quadruple register is simply the recording apparatus for the instruments connected with the electric circuit. The six pairs of wires already mentioned are here provided with as many electromagnets, actuating six pens, which trace their separate records in spiral lines around a revolving cylinder or drum. The pen connected with the anemometer draws a straight mark interrupted by notches, each of which stands for a mile of wind. The current moving the other five pens passes through the clockwork that drives the cylinder, by which the circuit is closed at intervals of one minute. Accordingly, once a minute the pen of the sunshine recorder is moved to the right or left provided the sunshine falling on the instrument has brought about the closing of the circuit there, otherwise the pen traces a straight line. The four pens of the wind vane, or anemoscope, make dots upon the paper before them in four parallel lines, so that a continuous north wind, for example, is registered by a single row of dots made at intervals of a minute, while a northwest wind produces two such rows.

Beside the wind-direction and velocity, and the sunshine, one other meteorological element, the rainfall, is recorded by this instrument, whence its name of "*quadruple* register." This is accomplished without employing an additional pen, by imposing a double duty on the pen of the sunshine recorder. The rain-gauge, which is situated on the flat roof of the observatory, has as usual a circular open top with a sharp edge, and the rain collected within this is conveyed to a tube below, of a section one-tenth as great in area. On its way it is temporarily arrested in a bucket, which holds the precise amount answering to a hundredth of an inch of rainfall, and which tips when it is filled, pouring its contents into the tube below. In tipping, it closes for an instant the electric circuit, moving the pen. The record of a shower is therefore like that of an equal period of sunshine, with the exception that the sidewise movements of the pen take place, if caused by sunshine, at equal intervals of a minute each, but if caused by rain, at irregular intervals, as often as a hundredth of an inch has fallen. Could rain continue with perfect steadiness at the fixed rate of one hundredth of an inch per minute, the trace would be indistinguishable from a sunshine record, but this probably will seldom or never occur. It happens however pretty frequently in this climate that sunshine and rain occur together; and it is then a matter of a little difficulty, though rarely enough so to be embarrassing, to pick out the marks which are to be assigned to the two independent records. The total rainfall, however, is not affected by this uncertainty, being always measured by the depth of water collected in the tube.

The quadruple register, together with all the instruments connected with it, is manufactured by Julien P. Friez of Baltimore, Md.

The Draper barograph is a mercury barometer, having its tube expanded in the upper portion into a greater calibre than below. This tube is rigidly supported by the frame, while the cistern is hung upon springs. The consequence is that the cistern sustains more of the weight of the mercury when the barometer is low than when high, and this weight forces it down, stretching the springs. A pen is attached to the cistern, and the record sheet is carried before it on a board, moved horizontally by clockwork. The top of the tube of this instrument having been broken out, it was repaired at the college. Although this work was done without the advantage of that close acquaintance with the instrument possessed by the makers, the Draper Manufacturing Co. of New York, the result has been fairly satisfactory; at least, the instrument gives a record which tallies with observations of the ordinary mercurial barometer far better than does the Richard barograph.

A shelter 30 inches deep and 6 feet high is attached in front of a north window of the observatory, but with a clear space of six inches, open on all sides, intervening between the shelter and the wall. The south face of the shelter, toward the observatory, is of glass, and since the observatory window is set in a recess, there is a well ventilated space of 17 inches in depth between the two glass surfaces. The instruments in the shelter are read through both panes, without opening the window, by means of a small telescope on a stand in the window frame. Thus the artificial heat of the observatory is, as completely as possible, prevented from penetrating to the interior of the shelter.

The instruments in this shelter are all designed to measure the humidity of the air. They consist of a stationary psychrometer by Henry J. Green, a registering psychrometer by Richard Frères, and a hair hygrometer of German manufacture. Beside these, there are kept in the observatory a dewpoint hygrometer and a Lowe graphic hygrometer, imported from Germany, and a sling psychrometer by Green. The latter is to be used in the open air outside the shelter, while the dewpoint instrument may be placed in the shelter when an observation is to be made. The principle of all these instruments, except the hair hygrometer and the dewpoint hygrometer, is that of the psychrometer; namely, there are two similar thermometers, the bulb of one of which is covered with a moistened piece of muslin. The rapidity of evaporation from this surface is determined by the dryness of the air, and itself determines the number of degrees of cooling, by which the wet-bulb thermometer is depressed below the height of the dry. The observation therefore consists in reading the two thermometers, and from these readings the humidity of the air is ascertained by the aid of printed tables.

The hair hygrometer is intended to indicate the atmospheric moisture in a very different way. Its index is attached to a hair or a vegetable fiber, which twists in one direction when the air is moist, and in the contrary when it is dry. This gives a more direct determination of humidity than the psychrometer, but unfortunately is not so trustworthy. The dewpoint hygrometer, on the contrary, gives a very accurate measure of the desired quantity, but gives it only as the result of an experiment, not to be performed without some little trouble. A surface is cooled by the evaporation of ether until dew is deposited on it from the air; the temperature at which this takes place indicates the amount of vapor present.

The foregoing instruments were not all received at the same time. Of those designed to give continuous records only the quadruple register and the Richard thermograph were in satisfactory operation at the beginning of January. In the monthly summaries for the first six months of the year, comprised in the present paper, the results from these instruments only, together with some data derived from the non-registering instruments, are included.

II. REDUCTION OF THE INSTRUMENTAL RECORD.

A sheet entitled "Daily Record" is made up from the observations of each day, and from the automatic registers. On this sheet a separate line is given to each of the twenty-four hours, and contains for that hour the registered values of the different meteorological elements. A certain amount of computation is also introduced, in order to resolve the observed wind-velocity for each hour into components in the directions of the four cardinal points. For this purpose, four columns are devoted to the number of minutes during which the four cardinal points have severally been recorded as the windward quarter. These numbers are obtained by counting the dots made by the four pens connected with the vane, in the successive hour-spaces on the quadruple register. Though this is of course a matter of frequency only, it is assumed as indicating the mean direction of the wind for the hour. For instance, if 13 dots are counted in the N. line, 34 in the E., 11 in the S., and 24 in the W., it is inferred that the mean direction or "bearing" of the wind is that of the resultant of forces proportional to these numbers, exerted in their respective directions, and accordingly equal to the angle of a right triangle the legs of which are respectively 13 — 11 or 2 and 34 — 24 or 10. A table, prepared for the purpose, having as arguments on each side the numbers from 1 to 60 inclusive, gives this angle in degrees and minutes. An apology is here necessary for introducing minutes into a computation, the terms of which are confessedly inexact, even when stated in whole degrees. The excuse is that in the specially prepared tables the statement of an angle in degrees and minutes involves little, if any, more labor to the user than if degrees only were given, and is necessary in order to secure a verifiable resolution of the velocity. The column of the "Daily Record" following the "bearing" is filled with the number of miles of wind in the total run for the hour in question, as given by the notches in the automatic trace of the anemometer. In the columns following, this hourly velocity is resolved into components along the meridian and perpendicular thereto, by a traverse table devised for the purpose. The construction of this table will be easiest understood by a sample page; accordingly, the table devoted to distance 1 is appended. It will be seen that if the bearing be N. 50° 15′ W., the northerly component is 0.6, because 50° 15′ is

	1.0	
18° 11′		71° 49′
	0.9	
31 47		58 13
	0.8	
41 24		48 36
	0.7	
49 27		40 33
	0.6	
56 37		33 23
	0.5	
63 15		36 45
	0.4	
69 30		20 30
	0.3	
75 31		14 29
	0.2	
81 22		8 38
	0.1	
87 08		2 52
	0.0	

between 49° 27′ and 56° 37′, while the westerly component is 0.8, because the same angle is between 48° 36′ and 58° 13′. There are tables for each whole number of miles in the hourly run, from 1 to 17 inclusive, and also for 50 miles. When the number of miles is between 17 and 34, the components are obtained by adding the figures obtained from two tables; from 34 to 49, by subtracting the quantity taken from one of the earlier tables from that derived from the table for 50; and for velocities above 50 miles an hour, again by addition. For velocities above 17, therefore, an occasional error in the tenths' place is to be expected. Aside from errors, the components of wind motion are thus derived for each hour, in miles and tenths, on the assumption that the whole run of wind for the hour may be treated as having blown from the point previously obtained as that of the mean direction.

Another but much briefer computation is made on the "Daily Record" for the purpose of finding the mean temperature of each hour. The highest and lowest indications of the thermograph in the course of the hour are recorded, and the mean between these two is taken as the hourly temperature.

III. TABULAR VIEW OF RECORD, JANUARY TO JUNE.

The successive columns of the Monthly Summary may now be explained. The first column, headed "Date," gives the day of the month. The next, under "Temperature, mean of 24 hours," contains the mean of the twenty-four hourly temperatures of the Daily Record, obtained as just stated from the thermograph. The third and fourth columns, "Max." and "Min." contain the readings of the maximum and minimum thermometers. The fifth and sixth, "Hours of Extremes," give the hours in which the thermograph record reached its highest and lowest points. The time given is that of the ending of the hour; thus "2 P. M." under "Max." means that the highest temperature of the day was reached between 1 and 2 o'clock. The six columns following, under the general head of "Psychrometer," give the results of the tri-daily observations of humidity, the registering hygrometric apparatus being not ready for use in the months here reported. The next or thirteenth column, "Barometer," gives in like manner the reading of the ordinary barometer, with no reference to the Draper barograph, the indications of which first became available during the spring months. The fourteenth column gives the total velocity of wind, as counted from the quadruple register. The next four, fifteenth to eighteenth inclusive, are the sums of the columns of components in the Daily Record, derived by the process described a little above. From these, the nineteenth and twentieth columns, headed "Equivalent," are obtained, by taking the resultant of the sums of components. The formulae of computation are as follows, D denoting the angle to be entered under "Direction" and M the number under "Miles":

$$\text{Log } (W-E) - \log (N-S) = \log \tan D.$$

$$\text{Log } (W-E) - \log \sin D = \log (N-S) - \log \cos D = \log M.$$

The twenty-first column, "Clouds at Observ'n," refers to the estimated cloudiness of the sky at the hours of observation, 6 A. M., 12 M. and 6 P. M. The proportionate part of the sky covered by clouds is estimated at each observation in tenths. Hence the numbers in this column range from 0, denoting a day perfectly clear at all three observation-hours, to 30, denoting a day in which the sky was overcast at morning, noon, and night. This column is given for the sake of comparison with the three columns following, which exhibit the record of the sunshine recorder.

The "Number of Minutes Actual Sunshine" as here given, means the number of minutes as recorded by the instrument. In view of the failure of the instrument to record the entire sunshine, particularly that of the opening minutes of the day, it has been recommended by the manufacturer to add a certain percentage to the instrumental indications. In some reports of cloudiness furnished by the observatory for publication in other compilations, this advice has been followed; but in the present report the figures are taken from the instrumental record without attempt at correction. It is therefore quite likely that some days here reported as having only 95 or 96 per cent. of sunshine were actually sunny from beginning to end. The numbers in the column of "possible sunshine" are the result of computations made in 1889 and published in "Colorado Weather" for April of that year.* The inequalities of the western horizon, due to the mountain range, were carefully measured, and their precise effect on the length of the day ascertained. This explains the irregularity of increase of the numbers in that column.

The twenty-fifth and twenty-sixth columns contain the hours of the earliest and latest rainfall occurring in a particular day, as shown by the quadruple register. During the cold months, the tipping bucket is removed from the rain gauge, to avoid damage by freezing. In these months, therefore, these two columns are left blank, unless the data for the entry happened to be given by a personal observation. The twenty-seventh column, however, containing the total amount of rainfall, is complete for the winter as well as the spring months, the entry including the amount of melted snow, when the precipitation was in that form.

Note on Elevation of Station. page 54.—In November, 1892, the elevation of the floor of the room containing the barometer, in Hagerman Hall, was determined by Mr. E. A. Sawyer, as 6,094.65 feet. The zero of the barometer scale is 4.27 feet above this level, while the floor of the observatory is 42.97 feet below it. A correction of 12.08 feet must be subtracted from the *datum* used by Mr. Sawyer, to conform to geodetic determinations at present accepted, making the elevation of the observatory floor 6,039.60 feet.

*The article here quoted is reprinted as part of the present Bulletin, forming No. 34.

MONTHLY SUMMARY OF

JANUARY,

DATE.	THERMOMETERS.					PSYCHROMETER.						BAR.	ANEMOM.	
	TEMPERATURES.			Hours of Extremes.		Relative Humidity.			Dew-point.			Actual Pressure at 12 M.	WIND.	
	Mean of 24 h.	Extremes. Max.	Extremes. Min.	Max.	Min.	6 AM	12 M.	6 PM	6 AM	12 M.	6 PM		Total Velocity	Sum N.
1	26.0	44	17	1 p.m.	8 a.m.	73	32	67	14	15	17	23.742	240	221
2	20.5	24	16	1 p.m.	12 p.m.	87	76	87	17	16	17	24.022	111	9
3	21.3	29	10	11 a.m.	12 p.m.	88	67	79	21	17	14	23.932	217	191
4	20.4	41	11	2 p.m.	3 a.m.	67	23	50	6	8	14	.949	147	75
5	25.0	39	15	1 p.m.	2 a.m.	72	24	48	11	6	11	.853	189	175
6	22.8	38	11	3 p.m.	7 a.m.	84	64	67	12	23	17	24.007	139	94.
7	34.9	53	18	3 p.m.	5 a.m.	72	11	25	11	2	1	.078	161	126.
8	36.0	55	23	1 p.m.	4 a.m.	59	13	23	8	8	3	23.876	181	147.
9	36.0	49	27	10 a.m.	12 p.m.	56	1	13	20	−28	6	.552	476	319.
10	27.0	38	8	3 p.m.	8 a.m.	45	29	36	−4	6	9	.855	155	94.
11	31.5	41	23	3 a.m.	8 p.m.	71	72	78	22	25	21	.902	242	203
12	34.0	44	21	12 p.m.	3 a.m.	54	48	28	11	17	11	24.085	333	194
13	44.9	62	20	12 m.	6 a.m.	54	7	7	11	1	−4	.163	355	181
14	37.3	53	21	3 p.m.	7 a.m.	55	17	31	12	7	8	.021	121	89.
15	39.9	52	20	12 m.	12 p.m.	40	11	39	21	2	16	23.945	226	....
16	39.3	60	17	2 p.m.	6 a.m.	76	3	10	5	−20	1	.941	216	125.
17	.....	.....	21	....	6 a.m.	39	21	33	3	8	10	24.090	139	....
18	.....	55	24	3 p.m.	....	34	14	14	19	8	4	23.663	362	....
19	28.8	40	16	1 a.m.	11 p.m.	50	31	57	14	8	15	.812	204	32.
20	22.3	35	10	3 p.m.	7 a.m.	89	70	52	10	21	16	.790	151	116.
21	21.6	32	10	12 m.	6 a.m.	90	44	47	12	14	10	.784	162	103.
22	17.6	30	6	4 p.m.	8 a.m.	41	52	87	−8	10	18	.725	168	126.
23	16.0	29	1	11 p.m.	6 a.m.	86	48	72	2	5	16	24.025	167	69.
24	30.8	44	16	1 p.m.	3 a.m.	63	11	17	12	−4	0	23.783	258	115.
25	15.6	26	3	1 a.m.	12 p.m.	56	49	82	5	7	8	24.097	255	.....
26	20.2	35	3	2 p.m.	1 a.m.	72	29	38	11	6	7	23.985	207	106.
27	17.4	27	3	11 a.m.	7 a.m.	77	26	34	0	0	0	24.028	180	164.
28	14.3	25	−1	3 p.m.	8 a.m.	8	10	48	...	19	5	.141	131	91.
29	28.2	40	15	2 p.m.	6 a.m.	56	29	25	5	9	5	23.936	267	148.
30	26.9	35	16	11 a.m.	12 p.m.	32	78	87	6	21	19	.915	370	307.
31	20.8	38	8	4 p.m.	4 a.m.	88	50	64	6	14	13	24.087	119	98.
Sums,	.....	.....	.....	....	....	...	...	...	...	...	...	......	6649	3728.
Means,	26.8	40.4	13.8	....	....	62	34	47	10	7	10	23.929	.....	.....

INSTRUMENTAL RECORD.

1904.

TER AND ANEMOSCOPE.					SUNSHINE RECORDER.				RAIN GAUGE.			
WIND.—Continued.					Clouds at Observ'n.	Number of Minutes.			Hours of Fall.		Total Amount.	Date.
of Components.			Equivalent.									
.	W.	E.	Direction.	Miles.		Actual.	Possible	Per Ct.	Earliest.	Latest.		
.7	46.9	15.0	N. 8° 15′ W.	222.5	17	447	529	84	0	0	0	1
.3	4.8	69.3	S. 47° 33′ E.	87.4	28	146	529	28	0	0	T	2
.3	21.1	34.1	N. 4° 01′ E.	185.5	16	386	530	73	0	0	0	3
.4	16.3	47.5	N. 51° 24′ E.	39.9	5	436	531	82	0	0	0	4
.3	20.5	26.7	N. 2° 04′ E.	172.4	14	367	532	69	0	0	0	5
.9	15.9	27.9	N. 9° 22′ E.	73.7	1	469	533	88	0	0	0	6
.4	22.3	20.4	N. 1° 02′ W.	105.1	0	498	533	93	0	0	0	7
.1	21.7	20.9	N. 0° 22′ W.	126.4	0	500	534	94	0	0	0	8
0	337.1	0	N. 46° 35′ W.	464.1	11	379	535	71	0	0	0	9
.3	63.3	25.8	N. 26° 19′ W.	84.6	4	458	535	86	0	0	0	10
.2	34.1	41.6	N. 2° 16′ E.	189.6	24	201	536	37	0	0	0	11
.7	190.2	40.8	N. 40° 08′ W.	231.8	12	311	537	58	0	0	0	12
.3	239.1	30.6	N. 53° 59′ W.	257.8	6	512	538	95	0	0	0	13
.4	24.9	14.1	N. 8° 54′ W.	69.8	5	494	540	91	0	0	0	14
...	......	......	....	......	2	443	541	82	0	0	0	15
.6	97.6	38.0	N. 29° 14′ W.	122.0	3	491	542	91	0	0	0	16
...	......	......	....	......	6	423	543	80	0	0	0	17
...	......	......	....	......	...	494	545	91	0	0	0	18
.6	6.4	129.4	S. 59° 35′ E.	142.6	0	488	546	89	0	0	0	19
.3	24.3	24.4	N. 0° 04′ E.	94.1	2	409	548	75	0	0	T	20
.8	51.7	41.3	N. 6° 34′ W.	90.9	7	335	550	61	0	0	0	21
.5	59.9	15.5	N. 21° 56′ W.	118.9	20	0	552	0	0	0	T	22
.1	29.0	57.9	N. 74° 43′ E.	30.0	2	488	553	88	—		.03	23
.6	169.0	20.1	N. 57° 38′ W.	176.3	7	475	555	86	0	0	0	24
...	......	......	....	......	6	451	557	81	0	0	T	25
.9	90.0	27.0	N. 45° 19′ W.	88.6	2	422	559	75	0	0	T	26
.9	21.1	17.9	N. 1° 09′ W.	159.2	11	377	560	67	0	0	T	27
.5	10.5	31.6	N. 16° 38′ E.	73.7	0	507	562	90	0	0	T	28
.6	185.1	12.1	N. 51° 17′ W.	221.7	17	499	564	88	0	0	0	29
0	186.3	0.5	N. 31° 09′ W.	359.2	27	162	566	29	0	5 p.m.	.08	30
.9	26.4	21.7	N. 2° 46′ W.	97.3	3	518	568	91	0	0	0	31
.6	2015.5	852.1	....	......	...	...	...	...	....	....	.11	....
...	....	......	....	......	29%	...	...	75%	....	....	.....	....

MONTHLY SUMMARY OF

FEBRUARY.

Date.	Thermometers.					Psychrometer.						Bar.	Anemom	
	Temperatures.			Hours of Extremes.		Relative Humidity.			Dew-point.			Actual Pressure at 12 M.	Wind.	
	Mean of 24 h.	Extremes. Max.	Min.	Max.	Min.	6 AM	12 M.	6 PM	6 AM	12 M.	6 PM		Total Velocity	Su N
1	40.1	54	20	1 p.m.	2 a.m.	38	17	10	11	11	2	23.767	380	20
2	27.6	43	15	9 p.m.	6 a.m.	70	60	38	9	18	11	24.038	159	4
3	26.1	34	15	5 p.m.	6 a.m.	73	52	48	14	16	11	.176	171	8
4	42.4	60	19	5 p.m.	1 a.m.	61	15	23	20	11	14	23.999	148	7
5	47.9	60	35	1 p.m.	5 a.m.	34	10	13	15	4	5	.615	331	4
6	35.6	48	20	1 a.m.	12 p.m.	23	19	21	8	3	1	.554	376	7
7	27.2	40	17	4 p.m.	2 a.m.	41	24	31	8	6	8	.859	167	5
8	20.9	30	12	3 p.m.	12 p.m.	89	49	52	12	13	10	.883	147	6
9	21.1	35	6	3 p.m.	6 a.m.	58	49	50	1	13	14	.942	121	4
10	16.9	30	–1	3 p.m.	6 a.m.	83	56	54	–3	14	11	24.255	189	5
11	32.0	52	10	2 p.m.	2 a.m.	65	27	44	3	18	21	.076	153	8
12	44.2	62	24	3 p.m.	3 a.m.	58	14	14	22	8	8	23.837	127	6
13	50.1	59	27	11 a.m.	12 p.m.	14	20	33	8	18	20	.771	537	17
14	26.8	37	15	3 p.m.	6 a.m.	43	33	53	6	10	18	24.162	[illegible]	41
15	....	62	20	....	12 p.m.	51	14	32	25	18	15	23.931	226	11
16	33.0	65	17	3 p.m.	3 a.m.	33	20	34	4	13	17	.696	121	5
17	29.9	39	24	3 a.m.	10 p.m.	81	71	89	26	22	22	.940	373	36
18	23.7	31	14	2 p.m.	3 a.m.	85	62	77	14	21	20	24.234	145	5
19	23.4	34	11	2 p.m.	4 a.m.	85	62	79	8	21	23	.084	143	7
20	31.8	46	19	1 p.m.	1 a.m.	49	21	27	13	9	7	23.850	173	13
21	23.2	30	16	4 p.m.	2 a.m.	86	75	59	16	17	17	.912	106	17
22	52.6	66	29	4 p.m.	1 a.m.	24	30	28	16	25	25	.891	446	11
23	54.3	62	43	5 p.m.	12 p.m.	28	22	28	20	20	25	.939	342	4
24	44.9	64	27	8 p.m.	8 a.m.	73	49	31	24	28	27	24.037	142	24
25	59.9	69	40	12 m.	12 p.m.	32	11	12	33	11	13	23.900	.....	....
26	42.4	58	28	4 p.m.	6 a.m.	52	32	41	16	24	26	.957	.....	....
27	55.5	71	41	4 p.m.	1 a.m.	14	16	15	11	19	16	.722	.....	....
28	42.5	60	30	1 p.m.	7 a.m.	27	11	24	7	11	14	.714	221	94
29	.....	58	24	....	7 a.m.	65	41	8	15	21	–2	.996	136	54
....	....	....	....	....	....	...	...	...	...	...	...	......	......	....
....	....	....	....	....	....	...	...	...	...	...	...	......	......	....
Sums,	.....	....	....	....	....	...	...	...	...	...	...	......	5785	2266
Means,	36.1	50.3	21.3	....	....	53	34	37	13	15	14	23.922	.....	....

INSTRUMENTAL RECORD.

1904.

TER AND ANEMOSCOPE. WIND.—Continued. of Components. S.	W.	E.	Equivalent. Direction.	Miles.	SUNSHINE RECORDER. Clouds at Observ'n.	Number of Minutes. Actual.	Possible	Per Ct.	RAIN GAUGE. Hours of Fall. Earliest.	Latest.	Total Amount.	Date.
3.3	229.1	48.0	N. 45° 38′ W.	253.3	2	539	570	95	0	0	0	1
5.6	41.4	61.1	S. 44° 17′ E.	28.2	4	499	572	87	0	0	T	2
5.7	20.7	69.1	N. 70° 07′ E.	51.4	2	518	574	90	0	0	0	3
4.7	16.4	46.3	N. 41° 25′ E.	45.2	8	542	576	94	0	0	0	4
7.7	209.5	2.5	S. 59° 34′ W.	240.1	4	552	578	95	0	0	0	5
2.8	311.1	4.8	S. 89° 24′ W.	306.3	10	546	581	95	0	0	0	6
1.3	103.7	3.0	N. 88° 21′ W.	100.7	5	477	583	82	0	0	0	7
3.1	11.3	58.3	N. 71° 38′ E.	49.5	10	444	585	76	0	0	0	8
7.5	7.9	59.6	S. 85° 14′ E.	51.9	18	519	587	88	0	0	T	9
5.5	9.2	98.3	S. 70° 39′ E.	94.4	2	545	590	92	0	0	T	10
6.5	20.3	45.2	N. 34° 09′ E.	44.4	4	499	592	84	0	0	0	11
0.7	24.2	35.7	N. 19° 06′ E.	35.1	8	508	594	86	0	0	0	12
3.0	467.8	7.8	N. 72° 16′ W.	483.0	7	505	595	85	0	0	0	13
9.8	10.7	123.6	S. 62° 37′ E.	127.2	7	527	597	88	0	0	0	14
6.0	63.9	54.3	N. 11° 19′ W.	48.6	9	576	599	96	0	0	0	15
3.0	11.8	48.5	N. 55° 32′ E.	44.5	13	439	602	73	0	0	0	16
0	14.9	21.5	N. 1° 01′ E.	369.4	30	213	605	35	0	0	0	17
6.5	20.3	63.1	S. 85° 35′ E.	42.9	7	403	609	66	....	....	.10	18
7.8	10.6	50.2	N. 60° 31′ E.	45.5	16	527	612	86	....	....	.09	19
9.5	13.0	41.0	N. 13° 34′ E.	119.4	7	438	615	71	0	0	0	20
0.5	5.2	50.0	S. 46° 23′ E.	61.9	22	133	617	21	0	0	T	21
6.2	322.1	36.7	N. 83° 17′ W.	287.4	14	369	619	60	0	0	0	22
6.6	286.8	11.8	S. 78° 54′ W.	280.2	11	595	623	96	0	0	0	23
6.2	27.1	79.6	S. 59° 07′ E.	61.2	14	577	627	92	0	0	0	24
....	......	......	....	......	13	421	628	67	0	0	0	25
....	......	......	....	......	11	457	630	73	0	0	0	26
....	......	......	....	......	8	...	632	...	0	0	0	27
79.5	88.8	25.9	N. 76° 35′ W.	64.7	5	489	635	77	0	0	0	28
42.4	23.7	59.5	N. 71° 54′ E.	37.7	2	564	638	88	0	0	T	29
....	......	......	....	......	...	...	...	...	0	0	.....	....
....	......	......	....	......	...	...	...	...	0	0	.....	....
31.4	2371.5	1205.4	....	......	...	...	...	...	....	....	.19	....
....	......	......	....	......	31%	...	...	80%	....	....	....	....

MONTHLY SUMMARY OF

MARCH,

DATE.	THERMOMETERS. Temperatures. Mean of 24 h.	Extremes. Max.	Extremes. Min.	Hours of Extremes. Max.	Hours of Extremes. Min.	PSYCHROMETER. Relative Humidity. 6 A.M.	Relative Humidity. 12 M.	Relative Humidity. 6 P.M.	Dew-point. 6 A.M.	Dew-point. 12 M.	Dew-point. 6 P.M.	BAR. Actual Pressure at 12 M.	ANEMOM[ETER]. Wind. Total Velocity	Su[…] N
1	49.5	66	31	4 p.m.	7 a.m.	33	12	11	10	11	8	23.947	246	68
2	43.8	69	18	2 p.m.	11 p.m.	14	13	67	10	14	17	.791	724	328
3	23.9	39	10	4 p.m.	7 a.m.	62	14	33	0	14	10	24.301	208	48
4	. . .	65	25	. . . . . .	1 a.m.	59	12	15	23	11	11	23.795	248	142
5	33.0	42	22	4 p.m.	12 p.m.	54	17	36	19	0	17	24.103	440	382
6	40.2	60	21	4 p.m.	4 a.m.	43	17	30	6	14	21	.039	137	84
7	47.4	64	33	3 p.m.	2 a.m.	40	20	25	18	20	20	23.981	130	76
8	43.7	60	26	3 p.m.	5 a.m.	41	37	32	10	28	24	.797	185	57
9	44.0	56	31	1 a.m.	12 p.m.	38	6	19	26	-12	3	.438	576	138
10	38.0	49	23	4 p.m.	7 a.m.	59	17	14	8	4	4	.851	322	83
11	49.0	64	32	3 p.m.	3 a.m.	44	19	7	18	18	-4	.753	212	48
12	33.2	51	22	1 a.m.	12 p.m.	39	82	79	13	30	24	.918	181	62
13	32.4	46	16	4 p.m.	7 a.m.	72	56	8	11	20	-7	24.072	179	72
14	33.4	51	30	3 p.m.	12 p.m.	46	55	26	15	30	14	23.957	204	25
15	41.8	56	26	2 p.m.	5 a.m.	30	19	40	4	13	27	.855	206	105
16	33.0	39	31	1 a.m.	6 a.m.	81	75	100	26	29	32	24.009	204	151
17	41.9	52	25	2 p.m.	6 a.m.	89	27	26	26	18	20	.114	174	35.
18	52.6	65	37	5 p.m.	6 a.m.	28	22	37	16	20	34	23.905	175	80.
19	41.3	51	32	1 a.m.	7 a.m.	72	60	39	25	30	23	.932	271	15.
20	42.1	62	26	2 p.m.	5 a.m.	79	28	30	22	25	21	.471	310	78.
21	32.1	45	22	1 a.m.	12 p.m.	52	63	66	16	22	25	.697	207	97.
22	35.1	51	15	3 p.m.	6 a.m.	94	26	29	14	14	14	.965	172	48.
23	44.7	59	25	12 m.	6 a.m.	67	22	25	17	18	18	.656	323	34.
24	40.0	46	32	4 p.m.	10 p.m.	49	11	21	22	4	8	.664	347	134.
25	27.5	35	17	2 p.m.	12 p.m.	56	33	79	14	10	22	.867	285	45.
26	25.5	42	6	5 p.m.	6 a.m.	91	49	27	4	19	12	24.117	143	64.
27	31.2	41	22	5 p.m.	5 a.m.	63	81	42	12	26	19	.240	154	41.
28	46.7	62	26	1 p.m.	3 a.m.	49	24	38	19	24	32	23.753	233	90.
29	46.7	63	33	1 p.m.	5 a.m.	33	28	25	10	25	20	.498	239	121.
30	43.8	56	32	1 p.m.	6 a.m.	74	23	39	27	18	23	.556	175	80.
31	35.6	40	31	4 p.m.	12 p.m.	75	75	76	29	29	31	.955	241	191.
Sums,	. . .	. .	. .	. . . . . .	. . . . . .	. . .	. . .	. . .	. . .	. . .	. . .	. . . . .	7852	3038.
Means,	39.1	53.1	25.1	. . . . . .	. . . . . .	56	35	37	16	17	16	23.871	. . . .	. . . .

INSTRUMENTAL RECORD.

1904.

TER AND ANEMOSCOPE.					SUNSHINE RECORDER.				RAIN GAUGE.			DATE.
WIND.—Continued.					Clouds at Observ'n.	Number of Minutes.			Hours of Fall.		Total Amount.	
of Components.			Equivalent.									
S.	W.	E.	Direction.	Miles.		Actual.	Possible	Per Ct.	Earliest.	Latest.		
79.5	91.8	60.3	S. 71° 05′ W.	33.3	7	595	640	93	0	0	0	1
51.8	432.9	25.6	N. 55° 49′ W.	492.5	15	515	642	80	0	0	0	2
112.0	3.2	112.3	S. 59° 46′ E.	126.3	8	596	644	91	0	0	0	3
34.5	100.5	33.4	N. 31° 47′ W.	127.4	23	439	647	68	0	0	0	4
0	139.5	41.2	N. 14° 25′ W.	395.0	6	605	649	93	0	0	0	5
26.3	16.6	34.0	N. 16° 40′ E.	60.7	13	542	652	83	0	0	0	6
32.5	21.9	34.8	N. 16° 12′ E.	46.2	16	530	655	81	0	0	0	7
81.4	14.8	88.2	S. 72° 11′ E.	77.1	18	592	658	90	0	0	0	8
93.1	476.1	16.8	N. 84° 28′ W.	467.5	11	585	660	89	0	0	T	9
172.9	21.0	150.0	S. 55° 17′ E.	157.0	9	622	662	94	0	0	0	10
119.8	87.1	23.7	S. 41° 32′ W.	95.7	9	563	664	85	0	0	0	11
54.5	66.7	53.5	N. 58° 28′ W.	15.5	24	269	666	40	....	....	.02	12
32.3	67.5	62.8	N. 6° 37′ W.	40.7	3	636	668	95	0	0	0	13
111.6	18.7	116.1	S. 48° 30′ E.	130.1	9	448	671	82	0	0	0	14
56.1	69.9	33.8	N. 36° 06′ W.	61.3	16	475	676	70	0	0	0	15
29.6	6.0	46.9	N. 18° 32′ E.	128.7	28	153	681	22	....	....	.05	16
96.2	28.8	71.7	S. 35° 26′ E.	74.0	14	597	683	87	....	....	.03	17
42.0	77.6	37.1	N. 46° 23′ W.	56.0	22	616	686	90	0	0	0	18
148.5	36.9	167.3	S. 44° 29′ E.	186.1	11	629	687	91	0	0	0	19
125.6	173.0	34.0	S. 71° 15′ W.	146.8	9	391	689	57	5 p.m.	5 p.m.	.02	20
63.3	30.8	68.3	N. 48° 04′ E.	50.4	18	254	692	37	12 m.	12 m.	.01	21
86.9	45.8	38.5	S. 10° 38′ W.	39.6	6	557	694	80	0	0	0	22
221.0	134.9	35.0	S. 28° 08′ W.	211.9	26	521	695	75	0	0	0	23
92.1	209.5	22.7	N. 77° 08′ W.	191.7	7	487	697	70	0	0	0	24
180.9	8.7	149.7	S. 46° 09′ E.	195.6	14	404	698	58	0	0	0	25
39.2	11.6	74.3	N. 68° 21′ E.	67.5	14	334	700	48	....	....	.02	26
80.0	4.2	73.6	S. 61° 03′ E.	79.3	29	549	702	78	....	....	.05	27
37.3	138.5	29.2	N. 63° 53′ W.	121.8	10	645	705	91	0	0	0	28
26.3	133.4	22.7	N. 49° 22′ W.	145.9	7	635	710	89	0	0	0	29
17.4	65.2	30.2	N. 46° 20′ W.	48.3	16	527	715	74	....	....	.20	30
0	121.9	1.2	N. 32° 13′ W.	226.4	3	334	718	46	1 a.m.	10 p.m.	.20	31
2374.6	2865.0	1782.9	....	......	...	...	...	...	....	....	.60	....
......	......	......	....	......	45%	...	...	75%	....	....	....	....

MONTHLY SUMMARY OF

APRIL,

Date.	Thermometers. Temperatures. Mean of 24 h.	Extremes. Max.	Extremes. Min.	Hours of Extremes. Max.	Hours of Extremes. Min.	Psychrometer. Relative Humidity. 6 AM	12 M.	6 PM	Dew-point. 6 AM	12 M.	6 PM	Bar. Actual Pressure at 12 M.	Anemome- Wind. Total Velocity	Sum N.
1	29.4	33	26	5 p.m.	11 p.m.	89	81	82	26	26	28	24.324	175	58.6
2	36.4	49	23	3 p.m.	5 a.m.	89	85	61	22	30	31	.207	165	45.2
3	39.8	54	33	6 p.m.	7 a.m.	95	77	48	33	32	31	.140	134	35.4
4	41.9	57	33	2 p.m.	2 a.m.	61	49	51	25	37	30	.003	170	105.4
5	44.1	54	33	5 p.m.	2 a.m.	57	42	77	27	28	46	.232	236	.....
6	44.9	61	33	2 p.m.	5 a.m.	59	18	31	23	16	20	23.766	342	......
7	34.3	43	26	3 p.m.	7 a.m.	79	19	9	22	5	10	24.105	398	340.1
8	32.2	43	25	3 p.m.	5 a.m.	45	28	73	8	11	26	.088	371	344.3
9	40.3	59	20	4 p.m.	5 a.m.	75	25	16	17	18	11	.206	115	45.1
10	57.6	73	38	3 p.m.	1 a.m.	19	12	18	11	15	21	23.980	222	131.2
11	50.9	59	42	4 p.m.	6 a.m.	46	30	26	24	25	33	24.126	213	147.7
12	46.7	64	27	5 p.m.	6 a.m.	70	19	18	21	18	16	.203	119	37.7
13	57.5	71	37	3 p.m.	4 a.m.	24	9	21	16	10	27	.015	171	72.8
14	56.6	71	37	12 m.	5 a.m.	40	13	19	21	18	23	23.893	262	152.2
15	36.1	52	24	1 a.m.	12 p.m.	70	54	61	29	23	20	24.117	301	156.6
16	31.1	44	15	5 p.m.	6 a.m.	72	43	31	11	16	16	.066	336	3.0
17	47.0	59	22	5 p.m.	2 a.m.	61	31	34	25	27	30	.000	183	51.9
18	50.6	65	32	5 p.m.	6 a.m.	52	20	10	21	20	4	.075	252	51.6
19	54.8	71	37	1 p.m.	4 a.m.	72	1	15	34	−15	19	23.871	219	69.7
20	60.9	73	46	4 p.m.	11 p.m.	38	15	31	26	19	32	.776	269	24.4
21	44.8	53	41	12 m.	9 p.m.	86	33	13	39	20	−1	.515	648	233.8
22	53.0	67	42	5 p.m.	5 a.m.	19	10	11	6	4	11	.782	380	77.7
23	51.0	63	35	2 p.m.	4 a.m.	42	12	18	19	2	16	.714	386	160.9
24	39.3	44	30	1 p.m.	6 a.m.	100	66	60	32	32	30	24.007	690	......
25	47.5	55	33	2 p.m.	6 a.m.	67	7	45	26	1	30	.159	202	43.4
26	45.0	54	35	6 p.m.	9 a.m.	63	60	46	28	30	32	.070	168	6.8
27	53.8	70	32	4 p.m.	6 a.m.	91	17	22	32	24	29	23.985	179	36.3
28	59.2	72	40	2 p.m.	6 a.m.	73	9	17	36	10	21	.865	256	36.8
29	48.5	52	43	2 p.m.	7 p.m.	41	49	68	26	32	36	.882	433	364.3
30	45.2	52	38	11 a.m.	4 a.m.	77	48	74	33	31	38	.964	201	153.9
....	.....	.....	.....	....	....	...	...	...	...	...	...	.....	.....	......
Sums.	.....	.....	.....	....	....	...	...	...	...	...	...	.....	8196	2986.8
Means,	46.0	57.9	32.6	....	....	62	33	37	24	19	24	23.936	.....	......

INSTRUMENTAL RECORD.

1904.

TER AND ANEMOSCOPE.					SUNSHINE RECORDER.				RAIN GAUGE.			
WIND.—Continued.					Clouds at Observ'n.	Number of Minutes.			Hours of Fall.		Total Amount.	DATE.
of Components.			Equivalent.									
S.	W.	E.	Direction.	Miles.		Actual.	Possible	Per Ct.	Earliest.	Latest.		
82.0	7.6	79.2	S. 71° 54′ W.	75.3	27	308	721	43	1 a.m.	12 m.	.15	1
90.8	4.5	71.9	S. 55° 55′ E.	81.3	6	653	725	90	0	0	0	2
63.8	29.3	47.1	S. 32° 05′ E.	33.5	17	329	728	45	1 a.m.	8 a.m.	.02	3
15.9	89.0	3.4	N. 43° 43′ W.	123.8	16	356	730	49	0	0	0	4
......	......	......	....	......	4	692	733	95	0	0	0	5
......	......	......	....	......	8	...	736	...	0	0	0	6
0	136.0	15.9	N. 19° 27′ W.	360.7	12	...	739	...	0	0	0	7
0	24.7	67.8	N. 7° 08′ E.	347.0	16	242	742	33	0	0	0	8
52.8	17.9	23.9	S. 37° 56′ E.	9.7	1	718	744	97	0	0	0	9
5.4	118.9	12.0	N. 40° 21′ W.	165.1	13	681	748	91	0	0	0	10
20.2	25.4	67.8	N. 18° 24′ E.	134.3	17	643	752	86	0	0	0	11
52.4	3.0	59.3	S. 75° 22′ E.	58.1	0	706	754	94	0	0	0	12
39.4	56.7	37.7	N. 29° 38′ W.	38.4	13	554	756	73	0	0	0	13
0	176.5	5.6	N. 48° 19′ W.	228.9	18	550	759	72	0	0	0	14
49.6	15.9	142.6	N. 49° 49′ E.	165.8	24	14	762	2	0	0	0	15
234.8	0	234.4	S. 45° 19′ E.	329.7	12	602	764	79	0	0	T	16
91.2	17.5	83.6	S. 59° 16′ E.	76.9	17	510	767	66	0	0	0	17
143.2	19.0	131.9	S. 50° 57′ E.	145.4	7	635	769	83	0	0	0	18
59.0	135.7	23.0	N. 84° 34′ W.	113.1	21	533	771	69	0	0	0	19
168.0	36.7	124.8	S. 31° 32′ E.	168.5	5	640	773	83	0	0	0	20
57.2	501.0	59.5	N. 68° 12′ W.	475.5	22	422	776	54	0	0	0	21
78.5	268.0	52.8	S. 89° 47′ W.	213.4	0	732	779	94	0	0	0	22
159.9	143.2	11.6	N. 89° 34′ W.	131.9	16	551	782	70	0	0	0	23
......	......	......	....	......	24	386	785	49	4 a.m.	10 a.m.	.03	24
93.6	39.1	101.0	S. 50° 58′ E.	79.7	11	579	788	73	0	0	0	25
119.1	9.0	90.1	S. 35° 50′ E.	138.5	22	402	791	51	0	0	0	26
93.3	5.0	99.4	S. 58° 53′ E.	110.3	23	548	794	69	0	0	0	27
184.4	46.2	46.6	S. 0° 09′ E.	150.2	10	556	796	70	0	0	0	28
4.8	152.5	20.0	N. 20° 14′ W.	383.2	21	331	799	41	7 p.m.	7 p.m.	.03	29
0	38.8	18.9	N. 7° 22′ W.	155.2	23	296	800	37	0	0	0	30
......	......	......	....	......	...	...	...	...	....	....	.....	....
1859.3	2117.1	1751.8	....	......	...	...	...	...	....	....	.23	....
......	......	......	....	......	47%	...	...	66%	....	....	.....	....

MONTHLY SUMMARY OF

MAY,

DATE.	THERMOMETERS.					PSYCHROMETER.						BAR.	ANEMOME	
	TEMPERATURES.			Hours of Extremes.		Relative Humidity.			Dew-point.			Actual Pressure at 12 M.	WIND.	
	Mean of 24 h.	Extremes. Max.	Min.	Max.	Min.	6 AM	12 M.	6 PM	6 AM	12 M.	6 PM		Total Velocity	Sum N.
1	45.2	54	33	4 p.m.	5 a.m.	92	54	80	31	34	40	23.958	277	20.6
2	41.0	44	36	3 a.m.	6 p.m.	97	100	92	41	44	35	.777	434	45.5
3	44.0	52	37	5 p.m.	6 a.m.	85	49	69	34	32	37	.837	283	3.5
4	44.1	54	34	1 p.m.	5 a.m.	85	51	64	34	36	37	.839	126	62.0
5	52.0	63	40	2 p.m.	2 a.m.	48	28	46	31	27	36	24.017	161	65.5
6	55.6	72	38	4 p.m.	5 a.m.	47	27	21	25	29	27	23.932	167	88.6
7	50.0	57	40	3 p.m.	11 p.m.	56	93	42	38	44	28	.869	273	197.8
8	41.5	48	33	4 p.m.	4 a.m.	49	40	40	22	25	25	24.141	246	223.1
9	46.7	62	30	4 p.m.	5 a.m.	75	38	20	29	29	20	.156	154	33.3
10	59.0	73	38	3 p.m.	3 a.m.	46	11	12	28	15	15	23.997	179	95.5
11	55.5	63	46	5 p.m.	5 a.m.	47	24	29	29	24	29	.977	330	116.2
12	43.8	49	37	1 a.m.	5 a.m.	77	60	55	32	30	30	24.136	360	326.7
13	44.3	53	34	5 p.m.	6 a.m.	75	46	40	28	28	27	.198	164	5.0
14	53.5	68	36	5 p.m.	6 a.m.	76	33	52	30	35	47	23.973	138	38.9
15	54.2	63	46	10 a.m.	12 p.m.	52	30	38	37	30	32	.892	205	166.6
16	46.9	51	41	11 a.m.	12 p.m.	63	93	70	35	40	39	24.084	143	89.5
17	51.2	61	37	3 p.m.	4 a.m.	72	50	46	34	38	37	.145	179	64.9
18	59.5	72	40	4 p.m.	5 a.m.	74	14	29	38	25	34	23.962	146	44.8
19	61.1	76	44	3 p.m.	5 a.m.	49	27	52	32	37	47	.863	242	31.3
20	58.0	65	54	11 a.m.	6 a.m.	57	52	74	40	47	49	24.058	195	21.3
21	55.2	66	49	2 p.m.	7 a.m.	82	62	55	45	48	41	.120	224	115.9
22	61.0	72	45	5 p.m.	5 a.m.	71	58	30	42	54	34	.040	124	45.6
23	59.5	70	47	4 p.m.	3 a.m.	71	39	40	42	42	43	.012	283	153.4
24	62.8	78	48	3 p.m.	5 a.m.	88	14	21	49	24	27	23.750	222	78.9
25	54.7	59	45	1 a.m.	11 p.m.	81	94	75	42	50	40	.887	355	332.9
26	44.6	49	41	4 p.m.	6 a.m.	93	87	93	39	42	42	24.144	179	0
27	49.8	59	42	6 p.m.	5 a.m.	100	78	79	42	47	50	.050	209	21.4
28	55.9	64	48	1 p.m.	3 a.m.	76	32	33	43	31	33	.013	169	118.5
29	60.9	71	44	4 p.m.	3 a.m.	56	21	22	37	27	29	.089	205	42.9
30	62.4	74	44	2 p.m.	6 a.m.	65	23	22	39	33	31	23.980	171	58.0
31	58.5	72	48	11 a.m.	12 p.m.	57	45	45	40	41	39	.858	291	262.4
Sums,	.....	.....	.....	....	....	...	...	...	...	...	...	.....	6834	2970.9
Means,	52.7	62.4	41.1	....	....	70	48	48	36	35	35	23.992	.....	.....

INSTRUMENTAL RECORD.

1904.

TER AND ANEMOSCOPE. Wind.—Continued. of Components. S.	W.	E.	Equivalent. Direction.	Miles.	SUNSHINE RECORDER. Clouds at Observ'n.	Number of Minutes. Actual.	Possible	Per Ct.	RAIN GAUGE. Hours of Fall. Earliest.	Latest.	Total Amount.	DATE.
206.7	10.0	131.0	S. 33° 02′ E.	222.0	30	285	802	36	6 p.m.	10 p.m	.03	1
200.7	17.6	319.3	S. 62° 47′ E.	339.3	27	0	804	0	4 a.m.	10 p.m.	1.81	2
174.1	36.5	168.0	S. 37° 36′ E.	215.6	14	556	807	69	1 a.m.	8 p.m.	.56	3
23.7	27.3	52.2	N. 32° 37′ E.	46.2	23	487	808	60	0	0	0	4
21.4	72.1	36.7	N. 38° 45′ W.	56.5	19	495	810	61	0	0	0	5
32.4	55.5	29.4	N. 24° 55′ W.	62.0	11	733	813	90	0	0	0	6
5.2	93.6	56.2	N. 10° 59′ W.	196.2	23	348	816	43	10 a.m.	6 p.m.	.51	7
0	27.2	57.5	N. 7° 44′ E.	225.2	3	724	819	88	0	0	0	8
76.0	3.2	96.9	S. 65° 30′ E.	103.0	1	725	822	88	0	0	0	9
57.6	33.0	37.9	N. 7° 22′ E.	38.2	18	623	824	76	0	0	0	10
148.6	13.9	157.5	S. 77° 17′ E.	147.2	8	717	827	87	0	0	0	11
3.6	69.0	21.5	N. 8° 22′ W.	326.6	22	338	829	41	0	0	0	12
101.5	0.8	116.3	S. 50° 08′ E.	150.6	11	586	832	70	0	0	0	13
67.6	31.1	37.3	S. 12° 11′ E.	29.4	19	640	833	77	0	0	0	14
17.4	19.7	49.3	N. 11° 13′ E.	152.1	21	570	834	68	1 p.m.	2 p.m.	.03	15
37.4	32.3	13.1	N. 20° 14′ W.	55.5	27	124	835	15	11 a.m.	12 p.m.	.19	16
89.6	9.9	57.5	S. 62° 34′ E.	53.6	10	690	836	83	0	0	0	17
73.9	12.8	57.8	S. 57° 07′ E.	53.6	11	659	837	79	0	0	0	18
111.9	2.7	158.6	S. 62° 40′ E.	175.5	19	605	839	72	0	0	0	19
116.2	14.2	100.6	S. 42° 19′ E.	128.4	20	337	840	40	1 p.m.	2 p.m.	.04	20
63.4	50.1	48.3	N. 1° 58′ W.	52.5	20	494	841	59	7 a.m.	8 a.m.	.03	21
48.3	13.7	53.7	S. 86° 08′ E.	40.0	4	675	843	80	0	0	0	22
84.6	27.0	84.9	N. 40° 05′ E.	89.9	9	672	845	80	9 p.m.	10 p.m.	.15	23
91.1	61.7	49.6	S. 44° 46′ W.	17.2	15	594	846	70	0	0	0	24
0	67.7	22.4	N. 7° 45′ W.	336.0	29	390	848	46	3 p.m.	5 p.m.	.46	25
124.1	0	127.5	S. 45° 46′ E.	178.0	30	120	849	14	3 a.m	12 p.m.	.25	26
95.3	15.1	142.2	S. 59° 50′ E.	147.0	20	397	851	47	1 a m.	5 a.m.	.06	27
19.8	42.8	23.9	N. 10° 51′ W.	100.5	15	655	852	77	0	0	T	28
113.8	3.2	113.1	S. 57° 11′ E.	130.8	5	805	854	94	0	0	0	29
74.4	15.4	71.3	S. 73° 39′ E.	58.2	15	741	855	87	0	0	0	30
0	36.3	17.7	N. 4° 03′ W.	263.1	14	751	856	88	0	0	T	31
2280.3	915.4	2509.2	....	......	...	...	...	...	....	....	4.12	....
......	......	......	....	......	54%	...	...	64%	....	....	......	....

MONTHLY SUMMARY OF

JUNE.

DATE.	THERMOMETERS. Temperatures. Mean of 24 h.	Extremes. Max.	Extremes. Min.	Hours of Extremes. Max.	Hours of Extremes. Min.	PSYCHROMETER. Relative Humidity. 6 AM	12 M.	6 PM	Dew-point. 6 AM	12 M.	6 PM	BAR. Actual Pressure at 12 M.	ANEMOME[TER] Wind. Total Velocity	Sum N.
1	60.1	74	43	3 p.m.	5 a.m.	54	24	33	34	32	35	23.910	224	123.9
2	53.9	60	49	6 p.m.	6 a.m.	65	72	59	39	44	43	.845	116	51.5
3	44.8	50	37	1 a.m.	10 a.m.	93	80	86	43	39	38	.747	267	271.8
4	49.2	58	41	1 p.m.	2 a.m.	71	45	66	37	35	41	.965	134	49.7
5	50.2	57	39	6 p.m.	4 a.m.	73	57	58	36	39	42	24.202	175	47.0
6	57.5	71	39	5 p.m.	5 a.m.	81	42	31	41	43	38	.079	158	49.7
7	63.7	78	46	2 p.m.	5 a.m.	57	17	38	39	27	41	23.984	229	62.4
8	....	65	50	4 p.m.	12 p.m.	77	74	74	46	49	49	24.037	206	121.5
9	50.6	56	46	5 p.m.	12 m.	81	94	67	41	46	43	.131	117	69.2
10	58.7	72	41	4 p.m.	5 a.m.	81	38	43	41	41	46	.079	128	44.2
11	58.4	75	48	11 a.m.	4 a.m.	72	71	72	45	51	45	.148	156	78.7
12	58.3	67	48	3 p.m.	4 a.m.	94	64	75	47	54	53	.159	191	61.1
13	55.0	64	49	6 p.m.	3 a.m.	88	80	75	48	54	52	.183	120	75.6
14	59.0	70	50	11 a.m.	5 a.m.	83	58	49	48	54	43	.080	110	57.0
15	63.6	74	52	12 m.	1 a.m.	39	19	50	39	28	41	.138	147	59.7
16	59.2	67	49	12 m.	6 a.m.	68	60	63	46	50	50	.167	131	69.6
17	62.7	76	50	10 a.m.	4 a.m.	68	26	43	46	38	41	.172	181	112.2
18	61.2	72	49	12 m.	4 a.m.	55	43	41	41	44	42	.167	169	110.2
19	62.8	75	47	4 p.m.	5 a.m.	71	30	33	43	38	41	.120	166	246.5
20	60.8	73	49	1 p.m.	4 a.m.	64	39	61	46	45	46	.096	186	77.9
21	59.5	70	50	3 p.m.	5 a.m.	78	60	70	47	52	49	.082	128	51.3
22	63.3	76	51	4 p.m.	5 a.m.	94	16	17	50	25	27	23.932	201	70.5
23	65.8	80	49	4 p.m.	5 a.m.	47	19	34	39	31	40	.984	145	59.3
24	64.1	81	51	2 p.m.	5 a.m.	68	20	44	46	33	42	.996	283	220.8
25	52.9	62	47	1 p.m.	5 a.m.	57	35	62	32	31	41	24.274	197	97.2
26	53.5	64	42	4 p.m.	5 a.m.	75	48	82	40	40	46	.233	210	6.7
27	60.4	76	44	4 p.m.	6 a.m.	82	33	30	43	41	38	.133	86	24.0
28	67.6	80	47	3 p.m.	5 a.m.	45	12	21	35	20	35	.088	174	132.4
29	63.6	74	53	3 p.m.	4 a.m.	60	36	60	44	43	52	.156	180	76.4
30	68.2	83	50	12 m.	5 a.m.	64	17	33	46	32	41	.134	156	71.9
31	....	....	....	....	....	...	...	...	...	...	...	....	....	....
Sums.	....	....	....	....	....	...	...	...	...	...	...	....	5071	2652.9
Means.	58.9	70.0	47.0	....	....	71	44	52	42	40	43	24.081	....	....

INSTRUMENTAL RECORD.

1904.

ter and Anemoscope.					Sunshine Recorder.				Rain Gauge.			Date.
Wind.—Continued.					Clouds at Observ'n.	Number of Minutes.			Hours of Fall.		Total Amount.	
of Components.			Equivalent.									
S.	W.	E.	Direction.	Miles.		Actual.	Possible	Per Ct.	Earliest.	Latest.		
34.8	93.1	34.9	N. 33° 09′ W.	106.4	17	614	856	72	10 p.m	10 p.m.	.02	1
40.6	15.1	33.9	N. 53° 32′ E.	23.4	16	459	857	54	11 a.m.	3 p.m.	.12	2
0	22.2	14.8	N. 1° 34′ W.	271.9	30	152	858	18	4 a.m.	6 p.m.	.28	3
41.8	29.6	59.4	N. 75° 09′ E.	30.8	21	458	859	53	3 p.m.	10 p.m.	.11	4
87.8	6.5	92.5	S. 64° 37′ E.	95.2	20	715	859	83	0	0	0	5
79.0	1.7	70.1	S. 66° 49′ E.	74.4	0	813	860	95	0	0	0	6
32.5	36.4	51.3	S. 12° 00′ E.	71.7	17	651	861	76	0	0	T	7
33.3	35.3	65.9	N. 19° 08′ E.	93.4	29	314	862	36	5 a.m.	12 p.m.	.10	8
28.1	4.9	42.8	N. 42° 41′ E.	55.9	23	273	862	32	1 a.m.	2 p.m.	.33	9
58.9	8.4	56.7	S. 73° 04′ E.	50.5	0	807	862	94	0	0	0	10
23.6	55.3	29.5	N. 25° 05′ W.	60.8	16	469	862	54	12 m.	10 p.m.	1.38	11
81.4	14.7	84.3	S. 73° 44′ E.	72.5	24	569	863	66	6 p.m.	6 p.m.	.10	12
20.9	11.2	30.2	N. 19° 09′ E.	57.9	24	302	863	35	1 p.m.	4 p.m	.07	13
23.0	25.0	33.0	N. 13° 14′ E.	34.9	21	438	863	51	0	0	T	14
54.6	25.4	38.8	N. 69° 10′ E.	14.3	14	586	863	68	3 p.m.	4 p.m.	.07	15
29.3	35.4	27.9	N. 10° 33′ W.	41.0	15	680	863	79	1 p.m.	5 p.m.	.05	16
17.6	59.4	37.6	N. 12° 59′ W.	97.1	19	488	863	57	0	0	T	17
36.3	42.0	17.2	N. 18° 33′ W.	78.0	21	700	864	81	0	0	T	18
0	13.1	33.8	N. 4° 48′ E.	247.3	5	767	864	89	0	0	0	19
66.7	17.4	81.7	N. 80° 07′ E.	65.3	7	644	865	74	4 p.m.	5 p.m.	.24	20
50.6	20.2	45.2	N. 88° 24′ E.	25.0	19	600	865	69	1 p.m.	12 p.m.	.05	21
52.2	120.6	16.9	N. 80° 00′ W.	105.3	12	754	865	87	0	0	0	22
60.9	19.5	49.0	S. 86° 49′ E.	29.6	10	742	865	86	0	0	0	23
33.6	67.6	26.3	N. 12° 27′ W.	191.6	5	767	864	89	0	0	0	24
77.9	6.3	54.0	N. 67° 58′ E.	51.5	25	452	864	52	4 p.m.	5 p.m.	.06	25
44.9	20.5	116.0	S. 34° 39′ E.	168.0	14	623	863	72	12 m.	8 p.m.	.49	26
49.7	19.0	16.1	S. 6° 26′ W.	25.8	4	795	863	92	0	0	0	27
0	80.6	5.9	N. 29° 26′ W.	152.0	11	847	863	98	0	0	0	28
68.3	39.4	46.3	N. 40° 25′ E.	10.6	7	738	863	86	7 p.m.	7 p.m.	.02	29
56.5	24.8	33.2	N. 28° 37′ E.	17.5	13	794	863	92	0	0	0	30
....	.....	.....	....	.....	...	...	...	...	....	....	.....	31
84.8	970.6	1345.2	....	.....	...			...	....	....	3.49	...
....	.....	.....	....	.....	51%	...	...	70%	....	....	.....	...

DETERMINATION OF NUMBER OF HOURS OF POSSIBLE SUNSHINE AT COLORADO SPRINGS.

By F. H. Loud.

[Reprinted from "Colorado Weather," April, 1889.]

The mountain resorts of the old world and the new are frequently compared in respect to the number of hours during which the sun, if unclouded, can be seen in the sky. This is a most important consideration to the resident and tourist, as in many places the shortness of the day is a serious drawback to enjoyment and to health; the question is also not without its significance in meteorology, for the time of the sun's disappearance behind the mountain marks, as is well known, the beginning of a rapid decline in temperature.

To ascertain the length of possible sunshine is not altogether an easy matter, unless it be done by direct observation. If one wishes only mean values for a month, it may be sufficient to estimate the average height of that part of the mountain line which the sun passes during the course of that month, and, taking into account the inclination of his path to the horizon, deduce the length of that part of the diurnal arc which is hidden by the hills, and then subtract the corresponding time from the whole length of the day. In carrying out this plan, much depends upon estimate; and much care is necessary to insure that the averages used are correct ones, since in some parts of the work an error in these may be multiplied in the result. It is much more desirable to have a fairly correct value of this important epoch for each day of the year; especially for the use, already suggested, of interpreting the records of automatic registering instruments.

Accordingly, in attempting to make this determination for Colorado Springs, the following plan was pursued: The horizon in the west—the direction of the mountains—was first surveyed with a transit, and the azimuth and elevation of each point at which there was any marked angle in the line of the mountain tops was taken. Forty points in all were thus observed, a number quite sufficient to give a fairly correct idea of the apparent height of this line in every part. A plat or chart of these points was then made, and the intervening segments of the line sketched in. In making this diagram it was not deemed necessary to draw a map of the sky-region in question by any of the methods of projection employed in accurate cartography. Rather the simplest possible scheme was used, of taking, on a sheet of section paper, equal lengths for degrees of azimuth along a straight line representing the true horizon, and erecting perpendiculars to this for the altitudes, using the same scale of length to the degree. It will be seen that this differs only slightly from the development of a projection on a vertical cylinder, tangent to the sphere around the horizon. The difference consists in the use of the lengths of the arcs of altitude in place of their tangents. To be precise, the position of a point on the sphere would be transferred to the tangent cylinder by rolling the sphere within the cylinder, so that the vertical circle passing through the point would be applied to the element of the cylindric surface. An indefinite number of points having thus been transferred, and the cylinder developed, the line appears in the position already described. The distortion is not great, as no point represented is far from the true horizon, and whatever distortion exists may be assumed to affect equally the position of the parallels and hour circles subsequently drawn on the chart, since they also are located by means of points of known altitude and azimuth.

To draw the hour circles, the most convenient plan appeared to be to compute trigonometrically, for any particular hour angle, the distances both from the pole and from the zenith at which the hour circle would meet each of two vertical circles, so chosen (by guess) as to bring the points of intersection pretty near the line of the mountain tops, and usually on opposite sides of that line. The formulæ are, (if l represent the latitude of Colorado Springs, h the hour angle, and a the azimuth of the vertical circles, and if the two distances sought, namely, those separating the point of intersection from the pole and the zenith, respectively, be denoted by p and z;)

$$\tan \tfrac{1}{2}(p+z) = \tan (45^\circ - \tfrac{1}{2} l) \cos \tfrac{1}{2}(a-h) \div \cos \tfrac{1}{2}(a+h);$$

$$\tan \tfrac{1}{2}(p-z) = \tan (45^\circ - \tfrac{1}{2} l) \sin \tfrac{1}{2}(a-h) \div \sin \tfrac{1}{2}(a+h).$$

Hour circles at angular distances of 16 minutes apart were successively computed, and it will be easily seen that the labor of computation was frequently lightened by having to use often the same value of $a+h$ twice successively, as well as always the same value of l. Then a third point on each hour circle was fixed by computing the azimuth and polar distance of its intersection with the true horizon by the formulae

$$-\tan a = \sin l \tan h, \qquad -\cot p = \cot l \cos h.$$

The computations performed, and the points of intersection transferred to the chart, it was found that the arc of the hour circle fixed by these known points was in almost every case so close to a straight line as practically to exhibit no curvature worth noticing. So also the scale on which polar distances were laid off on them turned out to be nearly uniform, at least enough so to enable the points at which they were crossed by any desired declination circles to be found readily by a graphical interpolation.

Accordingly, arcs of parallels of declination, at distances of one degree apart, were drawn across the sketched outline of the mountain tops. To obtain from the diagram the true interval of time which would elapse from the passage of a body, for instance, a star, across the meridian, until it would be situated in the line of sight touching the mountains, it was only necessary to know the declination of the star, to find the parallel of declination on the chart, observe where it intersects the line of the hilltops, and read the figures attached to the hour circle passing through the same point, or, if the star were not precisely on a circle as drawn, interpolating between the two nearest. But the effect of refraction has thus far been neglected, as well as that of the sun's semi-diameter, either of which tends to postpone the apparent time of setting. These two corrections were easily made at once by drawing a line, parallel to that of the mountain tops, below the latter, and at a distance sufficient to equal the mean effect of refraction and semi-diameter. Then, taking from the Natical Almanac the declination of the sun for any particular day of the year, the time from his crossing the meridian to sunset could be found from the diagram as just explained, except that instead of the true line of hilltops, the lower parallel to it should be used.

The interval of time thus arrived at is what is given under the head of "P. M. sun" in the annexed table. Though it may in a sense be called the length of the afternoon, it should be borne in mind that to obtain from it the mean time of sunset, one more correction is needed, that of "equation of time" or "sun fast or slow," and this correction amounts sometimes to twenty minutes or so; hence, the column of "P. M. sun" is not to be supposed to give clock time for sunset. Again, the length of the afternoon varies a little in different parts of the city. The figures obtained all depend, of course, upon the point from which the survey of the horizon was made, and this point was Colorado College.

The column of "A. M. sun" might have been obtained in a precisely similar way from a survey of the eastern horizon. A survey was in fact made, and it appeared that the elevation of the highest point in this direction was barely greater than a degree and a half, while the most of the horizon was not interrupted by hills at all. This being the fact, and a determination of the actual length of the semi-diurnal arc being thought desirable for certain uses, it was decided to adopt the latter as the length of forenoon, or "A. M. sun," the errors being of slight importance, and moreover of opposite senses, so as to offset one another. The column of "A. M. sun," as given below, therefore, is the length of time in which the semi-diurnal arc is described, without correction for inequalities in the sky line toward the east, nor for refraction or semi-diameter.

The sum of "A. M. sun" and "P. M. sun" is taken for the total possible sunshine for any day, and the monthly sums and means of this latter quantity for alternate days of each calendar month is appended.

JANUARY.

DATE.	A. M. SUN.	P. M. SUN.
1	4 40	4 9
3	4 41	4 9
5	4 42	4 10
7	4 43	4 10
9	4 44	4 11
11	4 45	4 11
13	4 46	4 12
15	4 48	4 13
17	4 49	4 14
19	4 51	4 15
21	4 53	4 17
23	4 54	4 19
25	4 56	4 21
27	4 58	4 22
29	5 0	4 24
31	5 2	4 26

Monthly total, 281 h. 22 m.
" average, 9 h. 5 m.

FEBRUARY.

DATE.	A. M. SUN.	P. M. SUN.
2	5 4	4 28
4	5 6	4 30
6	5 9	4 32
8	5 11	4 34
10	5 13	4 37
12	5 15	4 39
14	5 18	4 39
16	5 20	4 42
18	5 23	4 46
20	5 25	4 50
22	5 27	4 52
24	5 30	4 57
26	5 32	4 58
28	5 35	5 0

Monthly total, 280 h. 31 m.
" average, 10 h. 1 m.

MARCH.

DATE.	A. M. SUN.	P. M. SUN.
2	5 37	5 5
4	5 40	5 7
6	5 42	5 10
8	5 45	5 13
10	5 47	5 15
12	5 50	5 16
14	5 52	5 19
16	5 55	5 26
18	5 58	5 28
20	6 0	5 29
22	6 3	5 31
24	6 5	5 32
26	6 8	5 32
28	6 10	5 35
30	6 13	5 42

Monthly total, 350 h. 8 m.
" average, 11 h. 18 m.

APRIL.

DATE.	A. M. SUN.	P. M. SUN.
1	6 15	5 46
3	6 18	5 50
5	6 20	5 53
7	6 23	5 56
9	6 25	5 59
11	6 28	6 4
13	6 30	6 6
15	6 32	6 10
17	6 35	6 12
19	6 37	6 14
21	6 39	6 17
23	6 42	6 20
25	6 44	6 24
27	6 46	6 28
29	6 49	6 30

Monthly total, 381h. 3m.
" average, 12h. 42m.

MAY.

DATE.	A. M. SUN.	P. M. SUN.
1	6 51	6 31
3	6 53	6 34
5	6 55	6 35
7	6 57	6 39
9	6 59	6 43
11	7 1	6 46
13	7 3	6 49
15	7 4	6 50
17	7 6	6 50
19	7 8	6 51
21	7 9	6 52
23	7 11	6 54
25	7 12	6 56
27	7 14	6 57
29	7 15	6 59
31	7 16	7 00

Monthly Total, 430h. 10m.
" average, 13h. 53m.

JUNE.

DATE.	A. M. SUN.	P. M. SUN.
2	7 17	7 00
4	7 18	7 01
6	7 19	7 01
8	7 20	7 02
10	7 20	7 02
12	7 21	7 02
14	7 21	7 02
16	7 21	7 02
18	7 22	7 02
20	7 22	7 03
22	7 22	7 03
24	7 22	7 02
26	7 21	7 02
28	7 21	7 02
30	7 21	7 02

Monthly total, 431h. 8m.
" average, 14h. 22m.

JULY.			AUGUST.			SEPTEMBER.		
DATE.	A. M. SUN.	P. M. SUN.	DATE.	A. M. SUN.	P. M. SUN.	DATE.	A. M. SUN.	P. M. SUN.
2	7 20	7 2	1	7 0	6 44	2	6 25	5 57
4	7 19	7 1	3	6 58	6 40	4	6 23	5 54
6	7 19	7 1	5	6 57	6 37	6	6 20	5 52
8	7 18	7 1	7	6 55	6 34	8	6 18	5 47
10	7 17	7 0	9	6 53	6 32	10	6 15	5 45
12	7 16	7 0	11	6 50	6 30	12	6 13	5 38
14	7 15	6 59	13	6 48	6 28	14	6 10	5 34
16	7 13	6 57	15	6 46	6 26	16	6 8	5 32
18	7 12	6 55	17	6 44	6 23	18	6 5	5 31
20	7 11	6 53	19	6 42	6 18	20	6 3	5 30
22	7 9	6 52	21	6 39	6 14	22	6 0	5 29
24	7 7	6 50	23	6 37	6 13	24	5 58	5 27
26	7 6	6 50	25	6 35	6 12	26	5 55	5 24
28	7 4	6 49	27	6 32	6 8	28	5 53	5 18
30	7 2	6 47	29	6 30	6 5	30	5 50	5 16
			31	6 28	6 2			
Monthly total, 438h. 11m. " average, 14h. 8m.			Monthly total, 406h. 54m. " average, 13h. 8m.			Monthly total, 352h. 21m. " average, 11h. 45m.		

OCTOBER.			NOVEMBER.			DECEMBER.		
DATE.	A. M. SUN.	P. M. SUN.	DATE.	A. M. SUN.	P. M. SUN.	DATE.	A. M. SUN.	P. M. SUN.
2	5 48	5 14	1	5 12	4 34	1	4 44	4 11
4	5 45	5 11	3	5 9	4 30	3	4 43	4 10
6	5 43	5 10	5	5 7	4 29	5	4 42	4 10
8	5 40	5 7	7	5 5	4 27	7	4 41	4 9
10	5 38	5 4	9	5 3	4 25	9	4 40	4 8
12	5 35	5 0	11	5 1	4 24	11	4 40	4 8
14	5 33	4 58	13	4 59	4 22	13	4 39	4 7
16	5 31	4 55	15	4 57	4 21	15	4 39	4 7
18	5 28	4 52	17	4 55	4 19	17	4 38	4 7
20	5 26	4 48	19	4 53	4 18	19	4 38	4 7
22	5 23	4 45	21	4 52	4 16	21	4 38	4 6
24	5 21	4 43	23	4 50	4 15	23	4 38	4 7
26	5 18	4 39	25	4 48	4 13	25	4 38	4 7
28	5 16	4 39	27	4 47	4 12	27	4 39	4 7
30	5 14	4 35	29	4 46	4 11	29	4 39	4 8
			.			31	4 40	4 8
Monthly total, 323h. 2m. " average, 10h. 25m.			Monthly total, 278h. 47m. " average, 9h. 18m.			Monthly total, 272h. 34m. " average, 8h. 48m.		

[Although the statistical tables in the present publication extend over the first six months of the year only, the date of issue permits the insertion of an interesting communication, referring to phenomena of lightning observed in August. For this contribution, thanks are due to Mr. Frank C. Jordan, a member of the faculty of the Colorado Springs High School, who took the photographs which by his kind permission are here reproduced, and has written the following descriptive article.]

NOTE ON MULTIPLE LIGHTNING FLASHES.

BY F. C. JORDAN.

On the evening of August 27th, 1904, there occurred a very brilliant electrical display during which were numerous multiple lightning flashes, a characteristic of storms in this region. In an attempt to get some data for determining whether the paths of successive flashes were identical in shape, and also to determine time intervals, two flashes were photographed with a moving camera. These show the nature of the phenomenon, and also afford a solution of the problem. The camera was held in the hands and swung back and forth at a practically uniform rate.

Figure 1 shows a double flash, and on the other end of the plate the image of an arc light which was in the field of view. Because of an alternating current its image is a series of dashes.* This gives the method of measuring intervals between successive flashes of the same discharge. The frequency of alternation was 120 per second, the average number of dashes per inch on the plate 36; therefore the time value of an inch on the plate is 3 tenths of a second.

In Fig. 1 the flashes are .15 in. apart; therefore the time interval is .045 sec.

Fig. 2 shows more beautifully a multiple flash. Two weak flashes were photographed on the plate before the final

* These dashes can be more distinctly seen in an enlarged copy of this portion of the photograph. Fig. 3.

brilliant discharge, and are seen crossing the others at various angles. The main flash was at a distance of about 1½ miles, and had a vertical length of about one mile. On the negative can be seen eleven images, only four of which are of decided brilliancy. It may be seen that all are parallel even to the minutest detail, with the exception of the lower part of the first flash. The second plate has no arc light image, but since conditions were the same, the same rate of oscillation of the camera has been assumed. Measurements give the following intervals for the eleven flashes: .12, .05, .09, .0012, .0048, .025, .016, .004, .025, .206 sec. Total, .53 sec. Intervals of four bright flashes, .17, .09, .27 sec.

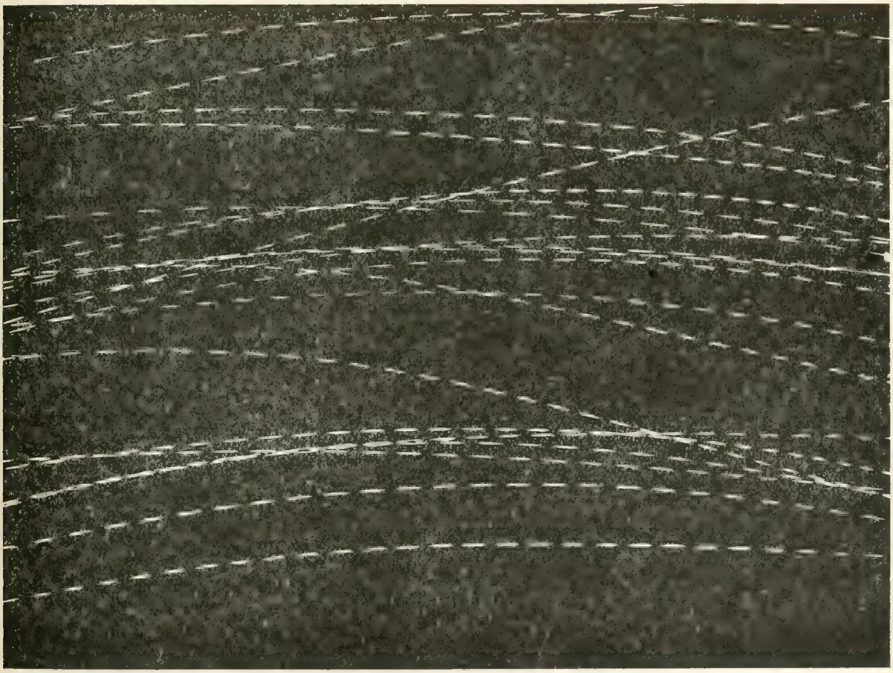

FIG. 3.

A noticeable peculiarity of both pictures is the white horizontal lines, extending to the left of the second flash in Fig. 1; to the right of the third brilliant flash in Fig. 2.

These may be accounted for in two ways: by assuming incandescence of particles in the air, or chemical dissociation of water vapor and consequent combustion of the hydrogen. It is also a peculiar fact that in neither case does this effect begin with the first flash. The greatest duration of this luminosity was about 3 tenths of a second.

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(*Continued on inside of back cover.*)

PLANT AND ANIMAL FERMENTS AND THEIR RELATION TO LIFE.

By Professor Edward C. Schneider.

[Read before the Science Section of the Colorado Teachers' Association. December 29, 1903.]

Biology today attempts to explain life entirely from the chemico-physical standpoint, it believes that all the phenomena of life will, in time, be explained, more or less completely, in terms of chemistry and physics. ''The fundamental conception of the living body as a physical mechanism,'' says Huxley, '' is the distinctive feature of modern as contrasted with ancient physiology.'' To see the truth of this statement it is only necessary to review some of the more common ancient and modern theories of digestion.

In one of the earliest theories, that held by the Egyptians and Hindus between the years 1550–700 B. C., is found the belief that digestion was performed by the aid of a ''deamon'' or spirit, and that indigestion was due to anger of this spirit, A prominent physician, Theophrastus von Hohenheim, or Bombastus Paracelsus, as he was often called, taught that digestion was carried out by a presiding force within the body, which he termed its ''archeus.'' This force separated the nutritious from the poisonous ingredients of the food, and also aided in the absorption of nutritious portions. Again Georg Ernst Stahl [1660–1734] was of the opinion that the force used in digestion, as well as all the other body processes, was the ''soul'' or supreme principle. According to his theory this was not the same as the spirit, but a special life-giving and life-preserving principle of the body. The system of Vitalism, introduced by Bordeu of Montpellier [1722–1776] held that *all* the phenomena of life, that of the digestion of food, production of heat, muscular force, and the mental processes were caused by the "vital principle."

Today we believe digestion to be merely a chemical phenomenon and that the absorption of food obeys well known laws of physics. This knowledge has been brought to light, since the beginning of the 19th century, by the careful and painstaking researches of a host of workers on physiological or life problems. Gillispie has said that "the outcome of more than 2000 years of inquiry into the manner in which food is altered in the body so that the nutritious part may be used up and the useless portion cast out, and into the processes by which the nutriment is built up into various solid and fluid constituents of the organism, may be summed up in one sentence."

"The active digestion of nutritive substances results from intimate chemical and physical changes brought about by the action of a force possessed by the living protoplasm of cells of which we as yet know nothing, but which constitute the most intimate element underlying that mysterious entity *Life*."

What the force within the cell is that produces the bodies responsible for these chemical and physical changes as yet is not known, but modern investigation has shed much light upon the bodies or substances bringing about these changes. These are the so-called unorganized-soluble ferments or enzymes found within the digestive fluids.

The term ferment is one with which all are familiar, but most commonly minute vegetable bodies, the moulds, yeasts, and bacteria, are thought of when it is mentioned. Today the bodies known by the name of Ferments may be divided into two classes:—The first class comprises the minute unicellular forms of plant and animal life usually described as micro-organisms. The fermentation which they cause is largely the result of their growth and development, and their action is so intimately connected with the life of the cell that it is instantly stopped by anything which either kills the organism or temporarily arrests its activity. The unorganized ferments, diastases or enzymes, as they are called, are the products of living cells, that is they are substances secreted usually by specialized cells of higher plants and animals, and unlike the first class do not constitute living entities. They have the property, under proper conditions, of facilitating chemical reactions between certain bodies without entering into the composition of the resulting products; furthermore they possess the power of bringing about an amount of chemical change which is out of all proportion to the quantity of enzyme present, while they themselves undergo no change while exerting the specific action.

The enzymes take a very important part in the phenomena of assimilation and disassimilation of foods. Most of the foods which occur in nature at the disposition of animals and the colorless plants are not directly assimilable, that is they are not in a form in which the living protoplasm of the tissues can absorb or use them. They must first be acted upon by an unorganized ferment or enzyme in order that they may be transformed into substances that can be absorbed and are assimilable and suitable for the construction of new tissue or the repairing of worn tissue. The following examples will make this clear. Starch, which serves as a food for all living things, is not directly assimilable. In man, before it can be used, it must be transformed into some absorbable form. It undergoes this transformation in the alimentary canal: in the mouth it encounters the enzyme ptyalin of the saliva; in the intestine, amylopsin of the pancreatic juice; and glucase or maltase of the intestinal juice, and thus is transformed into the sugars maltose and dextrose which are suitable for the formation of tissues or the production of the energy of motion and heat. The proteids of our diet, milk, eggs, meat, and the like, must also undergo a change into the simpler compounds proteoses and peptones under the influence of the enzymes, pepsin and trypsin, of the gastric and pancreatic juices before they can be used. Likewise the fats and oils must be subjected to the influence of the enzyme steapsin of the pancreatic juice. These preparatory changes so necessary in the food of mankind are found to occur in the food of all animals.

Phenomena of like nature are also met with in the vegetable kingdom. During germination the reserve substances, such as starch, cellulose, proteids, and fatty substances, of the seed are consumed by the developing plant. However before these reserve foods can be utilized they must first be transformed by enzymes into assimilable products. Many of the enzymes effecting these changes have been extracted from the germinating seeds and their action proven. For example amylase, the enzyme converting starch and dextrin into maltose sugar, is found widely distributed: it is found in barley, oats, rice, maize, in general in all cereals; in the tubers of potatoes; as well as in the leaves and shoots of different plants. This particular enzyme is of considerable importance industrially. In the brewery it appears in the malt and is used to convert the starch into the sugar which is later to yield the alcohol. It is also used in the preparation of maltose sugar and syrups.

The fungi, in fact all colorless saprophytic plants, secrete enzymes capable of transforming dead animal and vegetable substances, upon and in which they live, into absorbable and assimilable forms.

As was stated earlier in this paper the enzymes also play a very important part in the phenomena of disassimilation within the tissues of organisms, both plant and animal. The molecules of sugar, peptone, proteose, etc., the resulting products of the transformation brought about by the enzymes outside the tissues are again within the tissues built up into very complex compounds, either into protoplasm—the living portion of the body, or into complex substances such as glycogen (so-called animal starch) and fat which are stored away here and there until needed. When required by the tissues to furnish the energy necessary to sustain the activities of life these substances are again decomposed and this transformation is the result of enzyme activity. It is a well known fact that the glycogen of the liver and muscles is changed, little by little, into dextrose (grape sugar) as it is needed by the tissues. The nature of this change is suggestive of enzyme action and that it is due to an enzyme was proven by Pavy who first succeeded in isolating it from the liver. Furthermore Mendel and Underhill, and others, have demonstrated the presence of an enzyme in muscles having power to convert its proteid material into comparatively simple chemical substances. In plants when solid stored foods, insoluble in water, such as starch, are to be moved from one part of the plant to another requiring material for growth it can be done only by altering them into soluble substances. This too is accomplished by means of enzymes. Thus we see that two important works done by the tissues of plants and animals are made possible through the action of certain substances produced by the cells, namely the enzymes.

Recent investigations indicate that it is probable that some of the synthetic or constructive processes of metabolism, by which complex substances are produced from simple ones found in plant and animal life, may also be referable to the action of enzymes. The evidence in favor of this is not conclusive but it points to possible revelations of the future. It has recently been established that enzymes have a reversible action, that is under proper conditions they can construct or synthesize the same compound that they transform. For example it has been demonstrated that the enzyme maltase when added to a solution of maltose will cause inversion of the latter to dextrose. However a complete conversion cannot be obtained, but if this solution of partly digested maltose is then added to a fresh solution of dextrose, at a time when further inversion does not occur, it will be observed that a retransformation of dextrose to maltose takes place. It thus appears that the enzyme is not only capable of causing the hydrolytic decomposition but also the synthesis of maltose. The reversible action of this particular enzyme is extremely interesting and if the same can be proven of others it will explain many of the complex syntheses of plant and animal life. For a long time it has been believed that the enzymes acted only as hydrolyzing agents, as in digestion, etc., that is to say they caused the fixation of one or more molecules of water to the substance as they decomposed it. The evidence of the experiment given above shows clearly that the reverse must also be true.

It was also formerly believed—and is still held by many today—that the oxidative changes within the body whereby the heat energy and the energy of motion are set free were the results of the direct action of the vital energy within the living cell. Today it is known that there are a number of agents in existence in animal and plant bodies having characteristics of true oxidizing agents and the ability of producing a union of oxygen and certain bodies. These substances, which are enzymes known by the name of oxidases, are also secreted by the living cells. The oxidases have been found in wines, in latex of the lac-tree, in fungi, in the juices of many fruits, in juices of potatoes, beets and many vegetables, and in saliva, muscles, lung and liver of animals. They are so common that Effront has said "it is unquestionable that the phenomena of respiration and oxidation of vegetables and animals must be generally attributed to oxidases."

The enzymes are splendid heat producers and their role in this sphere of action in the living organism is undoubtedly of much importance. The heat set free by them is utilized by the cells for their maintenance and for the construction of new cells and tissues. This capacity of the living cell to secrete an enzyme, whose business it is to supply heat is admirably shown in the little yeast plant. When yeast is first placed in a solution of cane sugar it secretes an enzyme which transforms the sugar into an assimilable form. In order to use this nutritive substance and convert it into any part of the cell an absorption of energy is necessary. Furthermore the yeast has need of energy to maintain the normal activities so essential to its existence. The little heat set free by the chemical change of the cane sugar into simpler sugars is not sufficient to supply the above demand for energy, therefore in order to meet this deficiency the cell secretes a second enzyme which acts upon the sugar more powerfully than the first transforming it into alcohol and carbon dioxide. These two new substances are useless to the yeast cell but by their production the energy so much required by this plant for its maintenance is supplied.

Thus it has been shown that the enzymes play a very important part in the phenomena of life:—(1) that, under proper conditions, they prepare the food stuffs so these may be absorbed and used by the living tissues; (2) that when food materials, *e. g.*, glycogen and starch, are stored in the tissues of the animal or plant body and an active tissue, such as muscle, requires nutriment in order to perform its work efficiently, they again transform such stored materials into a form that is assimilable and easily carried to the needy tissue; (3) there is some evidence that the enzymes are responsible for the constructive or synthetic changes occurring within the tissues; and (4) it appears that they effect the chemical reactions, oxidation, etc., that supply the energy so necessary for life and its normal activities.

What then is the nature of these bodies, which have been designated enzymes? As yet no one, apparently, has succeeded in obtaining any of them in an absolutely pure state, hence we are necessarily deprived of any certain knowledge of their chemical nature. The figures of analyses of the purer preparations of enzymes give a chemical composition very similar to that of a number of proteids. Brücke's "pure" pepsin solution stands out as an exception, it fails to respond to the common proteid tests and is not precipitated by any of the proteid precipitants. However tests have shown this preparation to be a nitrogenous compound. The current opinion is that the enzymes are either similar in composition to the proteid or some derivative of the proteid molecule. All the enzymes are soluble in water and commonly soluble in glycerin. They are rapidly destroyed, when in solution, by elevated temperatures, and it is interesting to note in this connection that they are destroyed by a temperature just a little below that at which the majority of the proteids coagulate. A great many substances, such as chloroform, thymol, sodium-fluoride, which are distinct protoplasmic poisons do not interfere with the enzymes themselves. This gives a ready means for distinguishing between the action of organized ferments and the enzymes, since such substances stop completely the action of organized ferments.

The manner in which the enzymes bring about their characteristic changes has been the subject for a great deal of discussion and many theories. At present we recognize the existence of two theories. The one assumes that enzymes act chemically and that they have a definite chemical composition; the other considers the enzymes as properties or forces, and not as substances. The first offers a chemical, the second a physical explanation. At present facts indicate that they are bodies and not forces. There are a large number of examples of well known and simple chemical reactions (catalytic reactions) in which a special substance is placed in the reacting solution for the purpose of inducing a chemical reaction without itself becoming altered thereby. Enzyme actions, it is held, are such catalytic reactions. A case of the reaction alluded to is to be found in the action of sulphuric acid in the process of preparing ether from alcohol. It can be shown that the sulphuric acid first combines with a portion of the alcohol, forming a substance which may be readily isolated, and is known as ethyl-sulphuric acid; and that this compound then reacts with another molecule of alcohol, thus forming ether, and regenerating the sulphuric acid which is then free to repeat the process. While there is no experimental evidence to substantiate it, nevertheless there are so many points of similarity in the reaction that it is believed that the enzyme acts in like manner. A molecule of the enzyme may unite with a molecule of the substance undergoing change, an unstable compound may thus be formed which by a subsequent change yields the products of enzyme activity and the regenerated enzyme.

It is also interesting to note that properties which are supposedly characteristic of enzymes are also possessed by certain elements which are found only in the inorganic world, and that some of these elements produce changes similar to some of the enzymes. Reference is made to H. C. Jones's study of the "inorganic ferments" in which he prepared a number of colloidal solutions of such substances as platinum, gold, silver, cadmium, iridium, etc. In these solutions the finely divided metal exists greatly diffused. Such solutions have the power of inverting cane-sugar to dextrose and levulose sugars, the same as one of the enzymes. Furthermore certain poisons, such as hydrocyanic acid and mercuric chloride, which have the power of inhibiting or suspending the action of enzymes exert a similar influence upon these colloidal solutions or so-called "inorganic ferments."

Surely it seems that the study of the enzymes is opening pathways whereby it will be possible to penetrate more deeply into the mysteries of the so-called vital forces. Meischer has said "there remains then this great question to be fought out by the biologist of the future—Is it chemical composition or cell structure to which we must look as the ultimate basis of vital phenomena?" The investigations on the enzymes indicate that the answer to this question will be in favor of physical-chemical phenomena and strengthens the position of biology when it asserts that life processes can and will be explained from the chemico-physical standpoint.

THE ELASTIC MODULUS AND ELASTIC LIMIT OF RUBBER AND THEIR RELATION TO CHANGE OF TEMPERATURE.

[Reprinted from the *Physical Review*, Vol. XIX, No. 2, August, 1904.]

By J. C. Shedd and L. R. Ingersoll.

The fact that a loaded rubber tube will shorten when steam is passed through it has long been a striking experiment; it has also proven a somewhat puzzling one.

The first explanation suggested was that of a negative coefficient of expansion. Direct experiment upon short solid pieces of rubber has failed to support this view. Under all conditions the volumetric coefficient has been found to be positive.† A. E. Lundal‡ found the cubical coefficient to be positive and very large; also to increase rapidly with rise of temperature. He also confirmed the previous conclusions of W. Röntgen that the volumetric change due to stretching is very small. Further he found that the cubical coefficient of stretched rubber is identical with that of rubber not under stress. The linear coefficient of expansion as determined in the experiments above noted was found to be positive for rubber not under stress, but for rubber under stress seemed to be abnormal, now positive, now negative, and always dependent upon the stress. Lundel concludes: (I.) The temperature coefficient of linear expansion at a given temperature is positive for small values of the stretching force, but decreases and becomes negative as this force increases. (II.) That this coefficient under any given stress increases rapidly with rise of temperature, is negative for low values

† P. Joule, J. Pierre and P. Lebedeff; A. Winkelmann, Handbuch d. Physik, 2, p. 66, 1896.

‡ Wiedemann Annalen, Dec., 1898, p. 741.

of stretching force but positive for higher values. There is therefore an inversion temperature where the coefficient is zero, also this inversion temperature is higher as the stretching force increases. A review of these experiments leads one to conclude that the behavior of rubber cannot be adequately explained on the supposition of a negative cubical or linear coefficient of expansion.

A second explanation was advanced by G. Schmulervitsch.* He suggested that the linear coefficient like the cubical is always positive, but that a rise of temperature increases the elastic modulus. G. R. Dallander went further and gave an equation for the relation of the elastic modulus and the temperature.† Lundal‡ confirmed the equation of Dallander, finding an increase of about 11 per cent. between 0° and 60° C. He also found that the increase is smaller when the stretching force is increased. In arriving at this conclusion Lundal introduces no correction for the temperature dilatation of the rubber, and he significantly remarks in this connection that "it is strictly speaking uncertain whether the elastic modulus increases or decreases with rises of temperature." In the experiments for determining the elastic modulus a peculiar source of error is present which Lundal calls the "elastic-after-effect" (Nachwirkung). This seems to be somewhat of the nature of viscosity and is found to diminish as the temperature rises. According to Lundal this diminution goes on up to 50° C. and then increases. He does not, however, give much weight to his determination above 60° C.

The purpose of the present experiments was to extend the stretching force over a much greater range than heretofore and to study the elastic-after-effect. The first apparatus used was a simple hook support for one end of a common rubber band, with a weight-pan mounted at the other end. For load increments stamped rifle bullets were used which

* Pogg. Ann., 144, p. 280, 1871.

† Ofvers af. Vet. AK. Forh., 28, p. 703, 1871.

‡ Loc. cit.

were found to be remarkably uniform in mass and of approximately 10 grams mass each. The elongation was read with a cathetometer. A large number of readings were taken upon a single rubber band at room temperature; from 10 to 100 grams being used as load increments. Also various loads were placed on the *weight pan* and left for a number of hours or days and the readings then taken for both rising and falling loads. The following conclusions were reached:

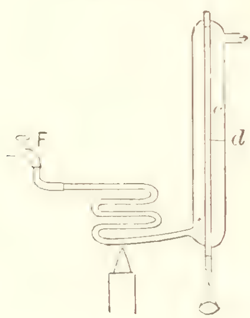
1. The same rising curves are traced whether the interval be one half minute, one minute or two minutes. The falling curves approximately coincide.

2. The return curve is never the same as the rising curve even for a small load range.

3. Hence the "elastic-after-effect" or viscosity factor cannot be eliminited by merely making an extra time allowance while taking the readings.

4. If the load exceed a certain limit the same cycle cannot

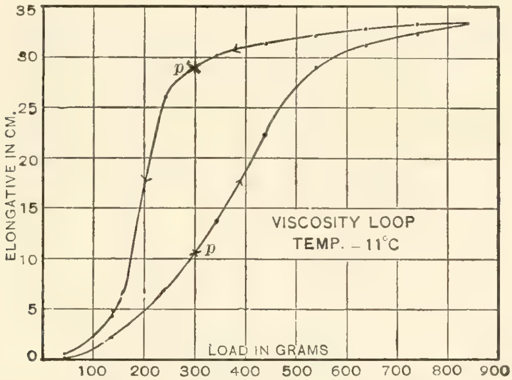
FIG. 1.



be repeated, *i. e.*, the rubber seems to receive a permanent set.

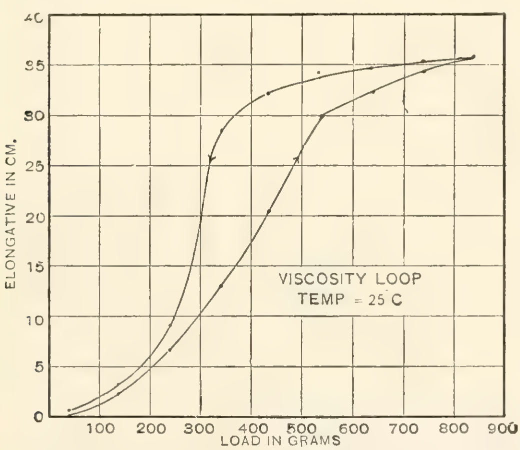
In order to vary the temperature the following simple scheme was used: A stream of water from the faucet *F* (Fig. 1) was passed through a glass tube bent back and forth and under which was placed a gas flame. The water after being heated was passed through the chamber *c* which surrounded the inner chamber *d*. By controlling the volume of water the temperature of the chamber *d* could be regulated quite closely. The range of temperature available was from 11° C. to 93° C. (the boiling point at this altitude being 94° C.). A large number of curves were obtained at different tempera-

FIG. 2.



tures and with different load limits; also different load increments were used as well as initial loads of various values, which were left on the weight pan for longer or shorter

FIG. 3.



periods. In all of this work the conclusions already given were confirmed to the fullest extent.

It was next thought worth while to try to eliminate the *per saltem* feature of the method of loading and unloading. This was done by mounting a Mariotte flask in such a way as to give a constant flow of water into a breaker which replaced the weight pan. A steady discharge rate was secured by mounting a siphon on a cork which floated within the beaker. Readings were taken at minute intervals, both rising and falling curves being secured. The results thus obtained showed that the curves gotten by the two methods do not materially differ. The easier method of fixed load increments was therefore again adopted.

THE ELASTIC MODULUS.

It was now apparent that the load limit above which a given cycle could not be repeated with a given specimen is very small. Data therefore obtained from the same specimen at different temperatures and for different load limits would not be strictly comparable and hence of no great value. It was also apparent that it would be practicably impossible to obtain a number of single rubbers exactly alike. A number of rubbers were therefore tested by means of a small load and their relative cross-sections determined. Combinations of rubbers were then made which were regarded as of the same cross-section. Care was also taken that the load limit should be low enough so that the rising and falling curves should be as nearly as possible parallel.

To the conclusions already noted may now be added those stated below. In reaching these conclusions the slope of the load-elongation curve is regarded as a function of the elastic modulus (see Figs. 2–8).

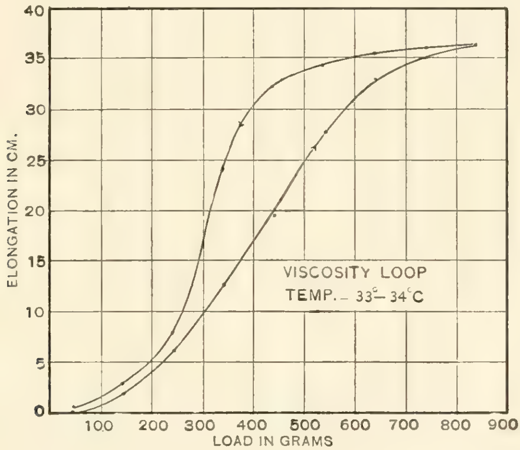
5. The value of E depends not alone upon the temperature but also upon the load.

6. For a given load the value of E seems to increase slightly with increase of temperature.

7. For a given temperature the value of E, beginning with zero load, slowly diminishes, then remains constant for a considerable range and finally sharply increases in value. The

first stage would seem to correspond to initial viscosity or static friction and the last to a permanent set. In the falling load the third stage is prolonged at the expense of the second.

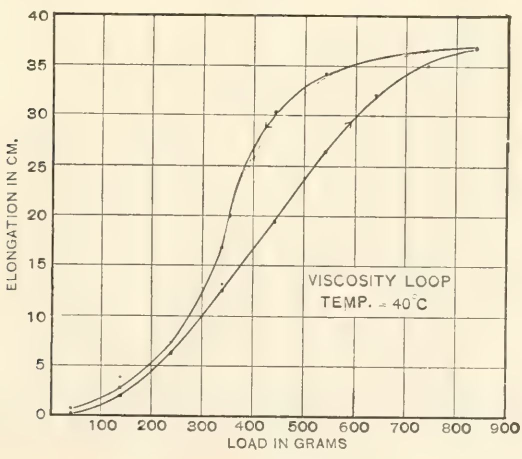
FIG. 4.



8. In case the third stage is not entered upon the return curve is more nearly parallel to the rising curve.

Energy Absorbed Due to Viscosity.—The fact that rising

FIG. 5.



and falling curves never coincide must be due to the irreversible action of viscosity. It is also apparent that the area of the curve, like that of the hysteresis loop, is a function of

FIG. 6.

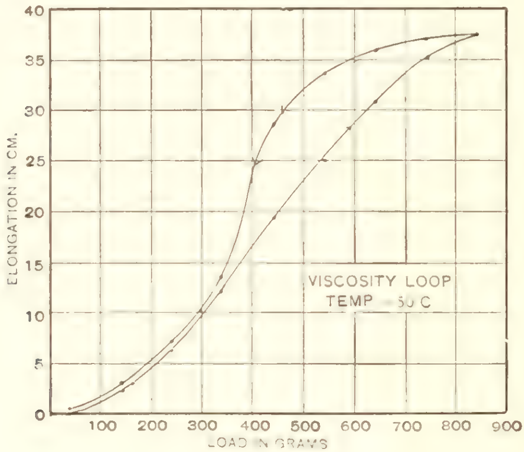
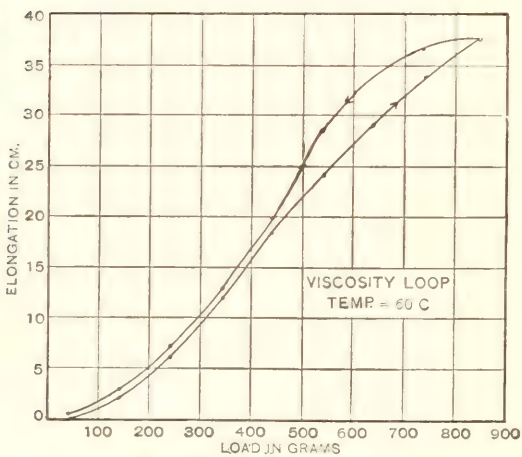


FIG. 7.



the energy absorbed. If then we compare the loops having the same range of load but taken at different temperatures we shall be able to compare the viscosities at these temperatures. Two series of such comparative areas are given in the following table:

Series I, Load limit 840 grams.

Temp. C.	Energy Absorbed per Cyele (comparative).	Temp. C.	Euergy Absorbed per Cycle (comparative).
11°	662	50°	338
25°	475	60°	179
34°	449	76°	129
40°	377	92°	145

Series II, Load lfmit 1080 grams.

Temp.	Energy Absorbed per Cycle.
18°	842
29°	535
36°	488
85°	152

The plat of these tables (Fig. 9) would lead to the conclusion that:

9. The energy dissipated per cycle due to viscosity depends upon the load limit, falls rapidly with rise of temperature, and becomes asymptotic to a fixed value.

ELASTIC LIMIT.

A study of the viscosity loops would seem to make two definitions of the elastic limit possible. In the first place on the rising curve there is seen to be a more or less well defined "knee" where the relation of stress to strain undergoes a marked change. This "knee" might be said to mark the elastic limit. The elastic limit so defined is found to rise as the temperature rises.

In the second place it is probable that a more comprehensive definition would be had by considering the descending curve also. The elastic limit would then be defined as that point above which the ascending and descending curves are no longer parallel. This point lies much lower down on the curve than does the first mentioned point, and it also rises as the temperature rises and at a somewhat faster rate. This second definition of the elastic limit could be given as follows: *The elastic limit is the limiting value of the stress (or strain)* *for which the body upon being released will repeat its previous history in exactly reversed order.*

This definition is more comprehensive in that it says that

FIG. 8.

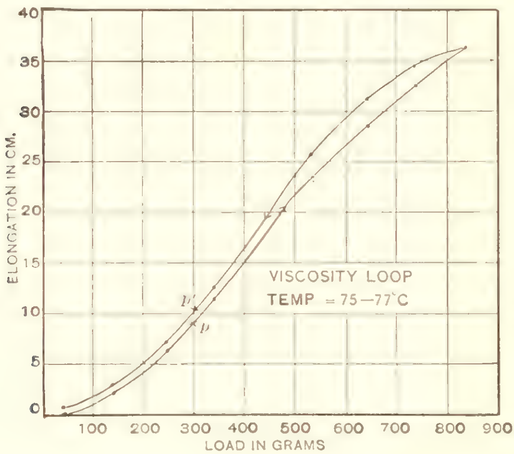
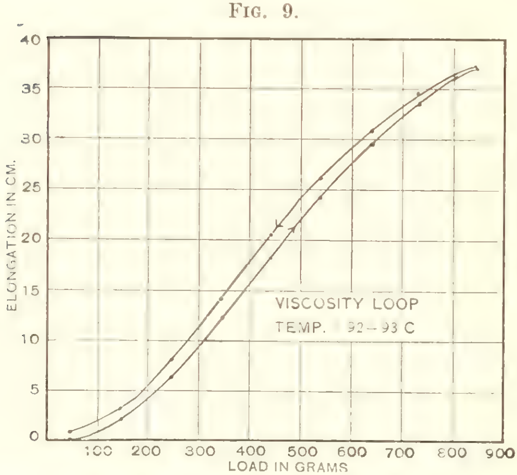


FIG. 9.



the history must be repeated in reversed order and not merely that the body must return to its original state.

We may now add to the previous conclusions the following:

10. The viscosity of rubber is relatively large at low temperatures, falls rapidly as the temperature rises, and reaches an approximately constant value at about 80° C.

11. The elastic limit of rubber rises with rise of tempera-

FIG. 10.

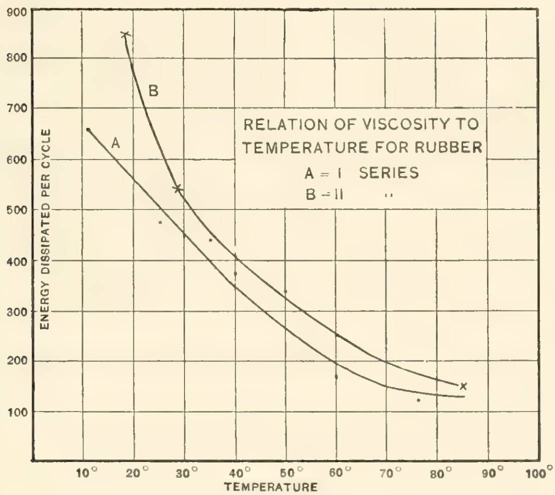
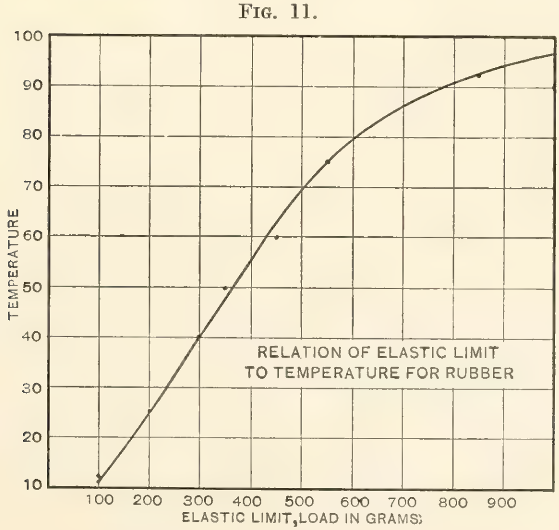


FIG. 11.



ture. The fact that the viscosity loop approached a constant area would indicate that the rise of the elastic limit is indefinite, limited only to the change of state of the rubber from a viscous solid to a viscous fluid (see plat 10).

A consideration of the viscosity loop affords a partial explanation of the behavior of the rubber tube spoken of at the beginning of this paper. Let us suppose that the temperature is 11° C., and that the load is 300 grams as shown on Fig. 2. On the rising curve this would be represented by the point *p*. However, if by chance, the rubber has been so handled as to have passed around the cycle then the point *p′* might more nearly represent the state of the rubber. Now if the temperature be raised to 75° C., points *p* and *p′* on Fig. 8 would approximately represent the state of the rubber. In the latter case the contraction would be 17 cm. as against 1.75 cm. in the former case, and would be due, not so much to an increase in the elastic modulus, as to a rise in the elastic limit.

SUMMARY.

We may conclude by dividing the history of a cycle into the following parts:

A. The first part of the curve has a small slope showing an apparently high value for *E*. This in a measure corresponds to the early stage of the magnetization curve of iron.

B. The second stage shows a comparatively constant but smaller value of *E*.

C. In the third stage the curve bends sharply showing a very high value for *E*. During this stage the rubber is in an abnormal state behaving very much like a metallic wire. This stage ends abruptly by the breaking of the rubber, or else the rubber receives a permanent set as is shown by the descending curve. As the temperature rises stage *B* is extended in both directions.

D. The form of the descending curve will depend upon whether or not stage "C" has been reached.

In conclusion it is apparent that all experimental work upon rubber should be conducted upon that part of stage *B* which lies below the elastic limit as defined in the second instance above. Also that the previous history of the specimen under test should be known.

PHYSICAL LABORATORY, COLORADO COLLEGE,
APRIL, 1904.

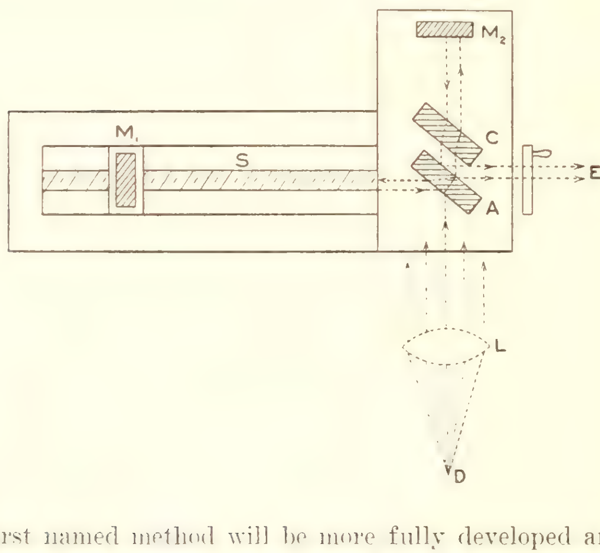
THE USE OF THE INTERFEROMETER IN THE STUDY OF THE ZEEMAN EFFECT.

[Reprinted from Physk. Zeit., Vol. 2, p. 278, 1901.]

BY JOHN C. SHEDD.

In a former paper* a comparison of the interferometer with the spectroscopic method was made. In the present paper

FIG. 1.



the first named method will be more fully developed and its use in the investigation of the Zeeman effect pointed out.

The Instrument, Figure 1, gives the ordinary view of the instrument.

* Physkal. Zeit., I, 270, 1900; Colo. College Studies, Vol. X, 1903.

M_1M_2 are two heavily silvered mirrors, the metal surfaces being toward A.

A is a plate of optically uniform thickness with the face toward M_2 silvered with a thin coating. (It is not essential to the operation of the instrument that plate A be "half" silvered, in recent instruments that have come under the writer's observation it is left unsilvered.)

C is a plate of the same optical thickness as A and placed parallel to it; it is called the compensator.

D is a source of light placed in the focus of lens L. D is the source of light that is to be investigated.

Mirror M_1 is mounted on a carriage which may be moved along carefully scraped ways by means of the screw S. The light from D, rendered parallel by the lens L, falls upon plate A at an angle of 45°. Part of the light is reflected and part transmitted by plate A. Each of these beams falls normally upon mirrors M_1M_2 respectively and retraces its path to plate A, where partial reflection and transmission again take place. An eye placed at E will therefore receive two beams of light, one reflected from mirror M_1 and the other from mirror M_2. Since both beams come from the same source and have traversed different length of path interference will take place. The theory of the resulting interference patterns has been discussed by Michelson* and by the present writer.† The condition for interference may be expressed by the following equation.

$$\Delta = 2\,\frac{t_0 + P\tan i \tan \varphi}{\sqrt{1 + \tan^2 i + \tan^2 \theta}} \qquad (1)$$

in which Δ is the difference of path between the two rays.

P is the distance of the plane upon which the interference is located from the mirror M_2.

ϕ is the angle which the mirror M_1M_2 make with each other. (Physically this is the angle by which they differ from 90°.)

† Phil. Mag., 13, 1882.

‡ Phys. Rev., XI, 5, 1900; Physkal. Zeit., Nov., 1901.

i and θ are the angles of incidence of the interfering beams upon the focal plane, i being in the plane parallel to and θ in the plane normal to the plane of ϕ. The focal plane is normal both to the plane of i and of θ.

$2t_0$ is the perpendicular distance between M_2 and the image of M_1 in M_2, this is controlled by the screw S.

In general Δ has all values, but the value which gives the most distinct fringes is determined by the conditions

$$\frac{\partial \Delta}{\partial \theta} = 0 \quad \text{and} \quad \frac{\partial \Delta}{\partial i} = 0.$$

This gives the value of P for which the interference fringes may be most distinctly seen. This value is,

$$P = \frac{t_0}{\tan \varphi} \tan i. \qquad (2)$$

In the practical use of the instrument the following values of P are of special interest, viz.

I. $\varphi = 0 \quad \therefore P = \infty.$

II. Δ or $t_0 = 0 \quad \therefore P = 0.$

In case I. the fringes are concentric circles located at infinity and in case II. they are straight lines located on mirror M_2. The focus of the eye must be suitably adjusted for the two cases. In case I., since the fringes are at infinity they should show no paralax as the eye is moved from side to side. This furnishes a ready criterion by which to judge this case.

The zero point of the instrument, where $\Delta = 0$ is characterized by the fact that with white light there is seen a central *black* band with beautifully colored fringes on either side. This central band is black instead of white from the fact that one ray undergoes internal and the other external reflection at the plate A. Hence a phase difference of $\frac{1}{2}\lambda$ is introduced. In addition to this phase difference due to reflection a dispersion* effect takes place in the compensating plate C unless it be strictly parallel to plate A and is of the same thickness.

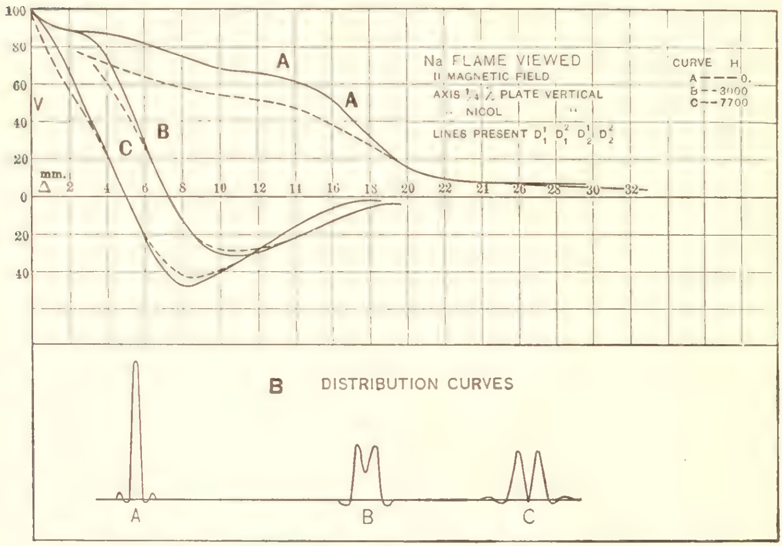
Having secured the zero point and also the colored fringes, one can by moving M_1 in either direction readily cause them to disappear. This is due to overlapping which soon obliterates the fringes. If light of one color be used the fringes continue to be visable for large values of Δ. In this case they become narrower as the value of Δ increases.

Visibility Curves. If a curve be platted with the intensity of the fringes as ordinates and the values of Δ as abscissas such a curve is called a visibility curve. If the source of light be a narrow slit of homogeneous light the curve falls slowly and becomes asymptotic to the axis of abscissas. The wider the source of light the more pronounced the overlapping and the more rapid the fall of the curve. In general the form of the visability curve depends upon the distribution of the light in the source. In particular we may note the form of curve for a double source or one having present two distinct wave lengths. It will be apparent, on even the slightest consideration, that this fact will produce a complete change in the visibility curve: the resultant system of fringes may be said to be due to the simultaneous presence of two systems corresponding to each of the two sources. Since the two components have different wave-lengths it is also apparent that there will be alternate reinforcement and destructive interference as the value of Δ increases. When the components are in phase there will be reinforcement and the fringes will be bright, and these points of maximum brightness will depend upon the value of the wave-lengths. The visibility curve will therefore periodically rise and fall, each successive maximum being lower than the preceding until the curve has fallen to zero. The distance between successive maxima, sometimes called the period, will be a function of the component wave-lengths and from it the difference between the wave-lengths of the components can be determined.

* Cornu, C. R., 93, 1881, Michelson Phil. Mag., 13, 236, 1882.

The general case would be that of a multiple light source with components of different intensity. Professor Michelson* has in the most elegant manner derived the solution of a number of visibility curves indicating the distribution of light in the corresponding sources. Such analysis in the cases of complex sources is most difficult and to avoid the great amount of work involved he supervised the construction of a mechanical harmonic analyzer which automatically traces out the distribution curve for any given visibility curve.

FIG. 2.



In the case of the Zeeman effect the general symmetry of the magnetized sources of radiation in a measure simplifies the problem. Nevertheless the practical analysis of a large number of such curves would be unattainable unless aided by the mechanical device.

The conclusion might therefore be drawn that it is impossible with the interferometer alone to make any substantial progress. Such a conclusion is unwarranted as will be seen from the following considerations.

* Phil. Mag., 13, 338, 1891.

(I.) The following conclusions may be drawn from the visibility curve without a complete analysis. In Fig. 2 curve A is the visibility curve for an unmagnetized line, curves B and C are the curves for field strengths 3000 and 7700 C. G. S. lines respectively. 1. The fact that curves B and C fall more rapidly than curve A indicates a broadening of the line. 2. The negative ordinates in B and C indicate that there are at least two centers of illumination present, so that the line is at least a double. The analysis of the curves by the harmonic analyser—shown in the lower part of Fig. 2—indicates the correctness of these conclusions.

(II.) It is also possible to determine the width of the equivalent single source. By this is meant the single homogeneous source whose visibility curve will be the envelope to the given visibility curve.

If Δ_1 be the value of Δ corresponding to $V = \frac{1}{2}$, then the half width (W) of the equivalent single source is

$$W = \frac{.22}{\Delta_1} \lambda^2 \qquad (3)$$

Table II.—given below—gives the values for W for the curves B and C in Fig. 2.

In determining the values Δ_1 it is necessary to consider a source of error present in the observations for visibility. It is a well-known fact that the eye will underestimate a faint illumination and overestimate a bright one. In the present case it is possible to test the eye by means of fringes of known intensity and thereby to obtain a correction curve. Such a curve obtained experimentally is shown in Fig. 3, and the dotted lines in Fig. 2 show the character of the required correction.

(III.) The state of polarization of the components can be determined in the most elegant manner, not only identifying the plane of polarization but also immediately identifying the accelerated from the retarded component. Thus let the light emerging from the magnetic field be examined as it is vewed parallel to the lines of force: then the perpendicularly polarized components may be isolated by means of a one-fourth wave plate and a nicol prism and separately examined. If now for different positions of the nicol the magnet be energized and the behavior of the fringe noted the retarded ray can be immediately differentiated from the accelerated ray. The following table will illustrate.

FIG. 3.

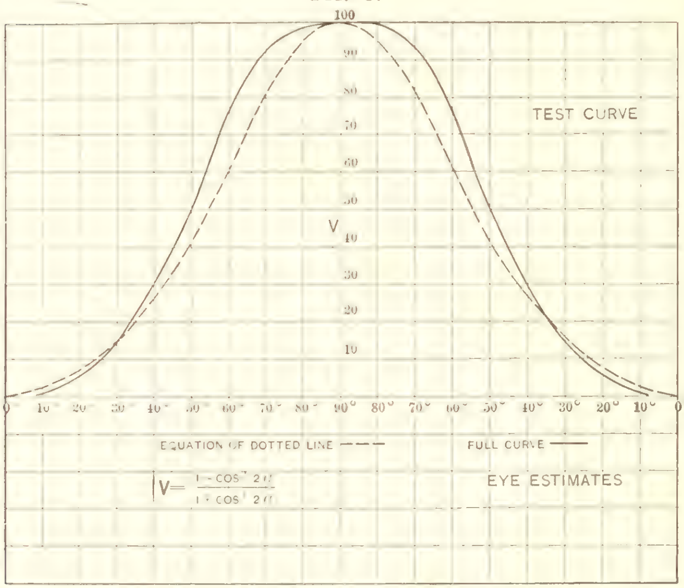


TABLE I.

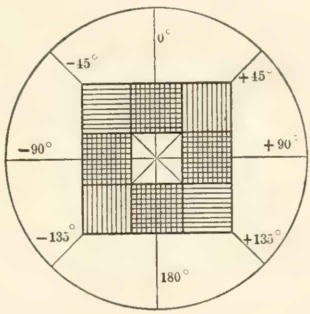
The position of the 1/4 wave plate remains undisturbed.

Position of axis of Nicol.	Action of fringes on magnetization.	Component present.
Vertical	Become hazy	Both
+ 45° or — 135	Expand and remain clear	Retarded component
± 90° (horizontal)	Become hazy	Both
+ 135° or — 45°	Contract and remain clear	Accelerated component
180° (vertical)	Become hazy	Both

When the fringes remain clear there is but one component present, a contraction of the fringes indicates the presence of the accelerated component (*i. e.*, the one of shorter wave-length) and an expansion of the fringes indicates the presence of the retarded component. The position of the prism indicates the plane of polarization. Table I. is graphically shown in Fig. 4. The overlapping portions indicate the presence of both components.

(V.) The interferometer is well adapted for the measurement of the change in wave-length due to the magnetic field. For this there are four methods, the same in principle but differing in detail.

FIG. 4.



1. Professor Michelson* in determining the difference in wave-length between the components of the magnetized line makes use of what he calls "the period of coincidence due to doubling." This may be defined as follows: consider two systems of fringes produced by light sources differing but little in wave-length. Then the resultant system will be due to the overlapping of the component systems and the fringes will run through a series of maxima and minima as Δ is increased. If Δ_1 be the distance from the zero of the instrument to the first maximum, then the following equation holds,

$$\Delta_1 = N\lambda = (N+1)\lambda_1 \qquad (4)$$

where N is the total number of fringes Δ_1 and λ and are measured in mm. In the case of the lines D_1D_2 these maxima occur every 988 fringes and the value of Δ_1 is 0.58242 mm. In the case of the magnetic shift the change of wave-length

* Astro. Phys. Jr., 6, p. 50.

is so small that Δ_1 ranges from 58 to 14 mm. as the magnetic field rises to 4000 C. G. S. lines. The same method is described by Perot and Farby* and is especially applicable where the difference of wave-length is sufficient to give a difference of color in the two sets of fringes.

When applied to the measurement of magnetic shift the method is open to criticism. In the first place the fringes, at a point where Δ is 50 or even 30 mm. are so narrow and frequently so faint that an acurate determination of the points of reinforcement is far from easy. In the second place since the magnetized and unmagnetized fringes cannot be simultaneously observed, the required determination consists in finding the value of Δ at which the closing of the magnet shifts the system the double width of one fringe. This determination for high values of Δ is far from easy.

2. In this method the nicol prism and the one-fourth wave plate are used but not simultaneously. It has been seen that the component systems draw apart, one expanding and the other contracting, when the magnet is energized. If now a point be found at which the two systems are tangent to each other, each fringe will have shifted one-half its own width, showing that the accelerated system is one-half period in advance of the retarded one, or one-fourth period removed from the original system. We then have the following equation.

$$\Delta_2 = N\lambda = (N + \tfrac{1}{4})\lambda_1 \qquad (5)$$

In this method the value of Δ must be found for which the fringes disappear and the field is of uniform brightness. The reason for this is that if the two systems are tangent to each other the bright fringes of one set will coincide with the dark ones of the other set, thereby quenching both. In viewing the light parallel to the lines of force the one-fourth wave plate is used but not the nicol, while if the light be viewed normal to the lines of force the nicol is so placed as to quench out the middle component. The two side components are

* Astro. Phys. Jr., Feb., 1899.

then observed but without the one-fourth wave plate. For observations normal to the lines of force this method may be regarded as the best one.

3. This method is applicable only to observation parallel to the lines of force and is as follows. The nicol is so placed as to quench one system of fringes, then such a value of Δ is found that the fringes are shifted over their own width. This may be ascertained in either of the following ways: the fringe is set with its edge to a pointer (fastened to the lens L), or the fringe is set tangent to a line drawn on one of the mirrors, or the attention is centered on the central fringe, then on energizing the magnet a dark central spot will become light. Having determined this value of Δ the following equation will hold:

$$\Delta_3 = N\lambda = (N + \tfrac{1}{2})\lambda_1. \qquad (6)$$

4. The fourth method is as follows: the magnet remains magnetized, then with the nicol in a given position set the fringe tangent to a line. The nicol is next turned through 90° bringing the other set of fringes into view, that value of Δ which renders this set tangent to the line is the value desired. The condition that the line is a common tangent to both sets of fringes gives a difference of period such that

$$\Delta_4 = N\lambda_1 = (N + 1)\lambda_2. \qquad (7)$$

Where $\lambda_1\lambda_2$ are the wave-lengths of the component lines. Also since λ_1 and λ_2 lie symmetrically with respect to λ (the unmagnetized line) we have

$$\Delta_4 = N\lambda_1 = (N + \tfrac{1}{2})\lambda = (N + 1)\lambda_2, \qquad (8)$$

or putting the equation in terms of λ,

$$\Delta_4 = N\lambda = (N \pm \tfrac{1}{2})\lambda_1. \qquad (9)$$

which is identical with equation (6).

All of these methods may be used when the light is viewed parallel to the lines of force. If viewed normal to this direction they are not all equally available. Thus one position of the nicol would give the central unaltered component while the perpendicular position would give *both* outside components. Method 1 is further complicated by the simultaneous presence of all three components. Methods 1, 3, and 4 are therefore not available. Method 2 alone remains and is entirely available.

In the foregoing N is the number of fringes counted from zero to Δ. Therefore $N\lambda = \Delta$ and the equations (4) to (9) may be written:

$$\left.\begin{array}{ll} \text{For (4)} & \lambda - \lambda_1 = \dfrac{\lambda\lambda_1}{\Delta_1} = \dfrac{\lambda^2}{\Delta_1} \\ \text{For (5)} & \lambda - \lambda_1 = \dfrac{\lambda\lambda_1}{4\Delta_2} = \dfrac{\lambda^2}{4\Delta_2} \\ \text{For (6) and (9)} & \lambda - \lambda_1 = \dfrac{\lambda\lambda_1}{2\Delta_3} = \dfrac{\lambda^2}{2\Delta_3} \end{array}\right\} . \qquad (10)$$

It further follows that for a given value of $\lambda - \lambda_1$ that

$$\Delta_1 = 4\Delta_2 = 2\Delta_3. \qquad (11)$$

This last equation gives a comparison between the four methods and would indicate that the second is the most accurate since it gives the smallest value of Δ which gives the widest and brightest fringes. This method however involves, as has already been pointed out, a uniform illumination, and it is found in practice that there is a region over which the fringes are blurred and the exact point of extinction is difficult to determine. On the other hand in the other methods the fringes are always sharp and clear and for values of H above 2000 C. G. S. lines the values of Δ are small enough to render the fringes sufficiently wide for satisfactory observation.

Equations (10) may readily be put in the form,

$$\frac{\lambda - \lambda_1}{\lambda^2} = \frac{1}{\Delta_1} = \frac{1}{4\Delta_2} = \frac{1}{2\Delta_3} \qquad (12)$$

It has been shown in a former paper* that

* Colorado College Studies, X, p. 45.

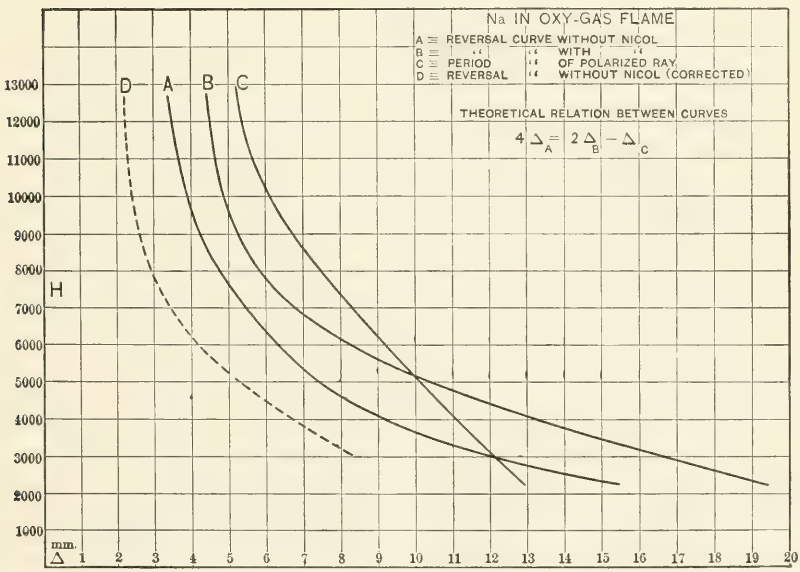
$$\frac{\lambda - \lambda_1}{\lambda^2} = \frac{e}{m} \cdot \frac{H}{4\pi v},$$

so that we may set down the following equations,

$$\left.\begin{aligned} &\textbf{Method 1,} && H\Delta_1 = 4\pi v \frac{m}{e} \\ &\textbf{Method 2,} && H\Delta_2 = \pi v \frac{m}{e} \\ &\textbf{Method 3 and 4,} && H\Delta_3 = 2\pi v \frac{m}{e} \end{aligned}\right\} . \qquad (13)$$

Regarding the ratio m/e as a constant these are equations of rectangular hyperbolas asymptotic to H and Δ taken as axes.

FIG. 5.



It is thus seen that curves expressing the relation between H and Δ furnish a ready comparison between the foregoing methods. Such a set of curves are shown in Fig. 5. Curves A and B corresponding to methods 2 and 3 show a close correspondence with equation (13) while curve C is manifestly wrong. Comparing curves A and B we see that equation (11) is not fulfilled and that one or both curves are displaced. Assuming that curve B is correct the dotted curve D gives the proper position for curve A.

Michelson's method for finding the half width of the equivalent single source has been outlined above. This equivalent half width will be also equal to $\lambda - \lambda_1$ and we can now compare results gotten by the two methods. In table II. such a comparison is given for the visibility curves shown in Fig. 2. $\lambda - \lambda_1$ is gotten by method 3.

TABLE II.

Value of H.	½ width of equiv. single source.	$\lambda - \lambda_1$
3000	0.17	0.13
7700	0.35	0.32

It will be noticed that column 2 gives larger values than column 3. This might be expected since $\lambda - \lambda_1$ is the mean difference while column 2 gives the extreme difference. Considering this fact the agreement may be regarded as very satisfactory.

(VI.) Measurements of the ratio e/m. For this, use is made of the equation,

$$e/m = \frac{\lambda - \lambda}{\lambda^2} \cdot \frac{2\pi v}{H} \tag{14}$$

where all of the terms on the right are known so that the ratio e/m can be evaluated. A table of values has already appeared in a previous issue of this series.*

In conclusion it may be said that the complete analytical method as developed by Michelson alone gives a full solution to the problem of the distribution of light in the magnetized source of light. The problem of the relation of change of λ to H, the problem of the polarization, and the problem of the ratio of e/m are solved by the methods described in this paper.

* Colorado College Studies, Vol. X.

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OF THE

COLORADO COLLEGE OBSERVATORY

CONTAINING THE

Annual Meteorological Summary

FOR 1904.

F. H. LOUD, PH. D., Director.

COLORADO SPRINGS, COLORADO

APRIL, 1905.

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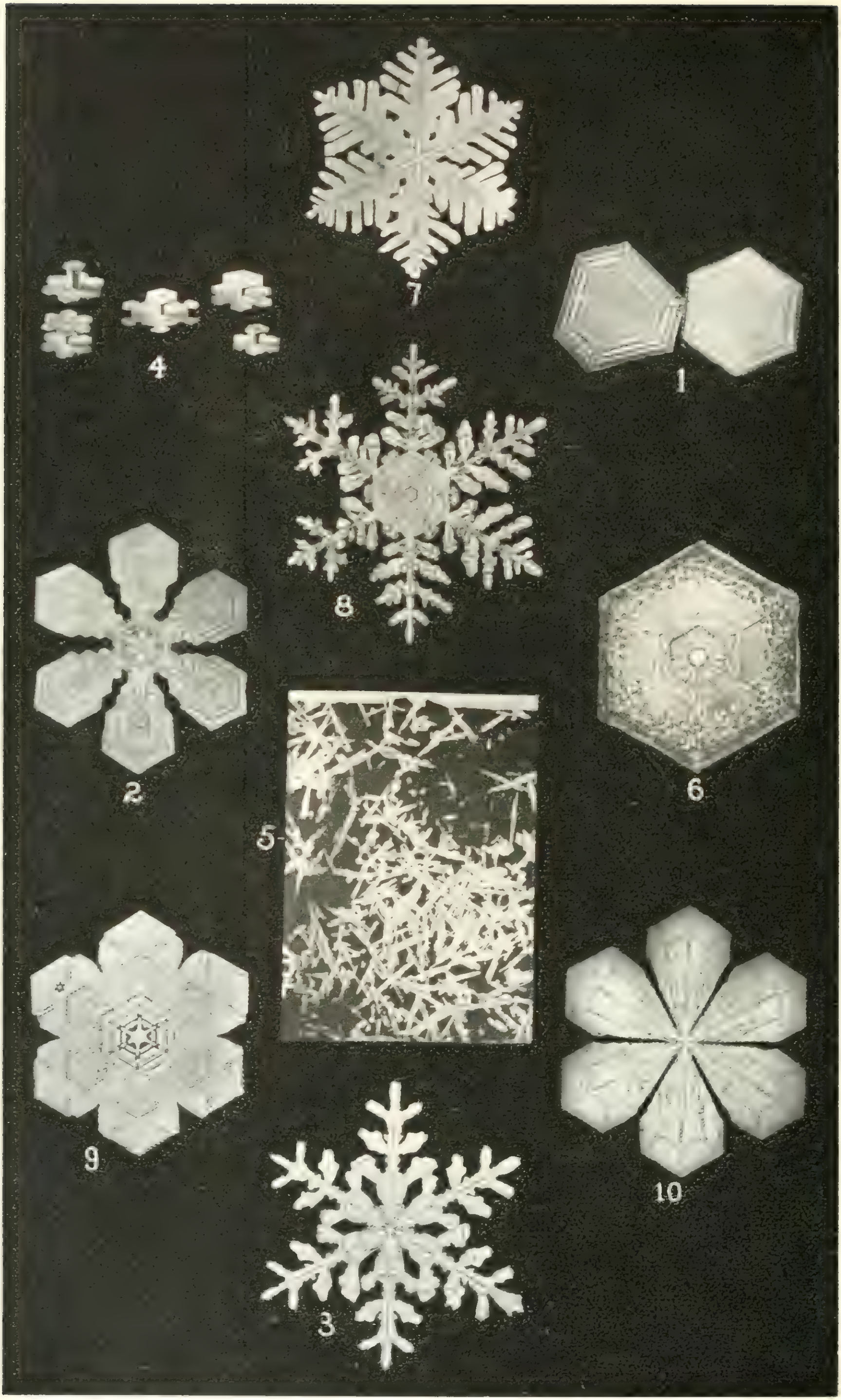
(Continued on inside of back cover.)



SNOW CRYSTALS. (Photographs by Bentley.)

Fig. 1.* Solid tabular.
" 2. Stellar nucleus.
" 3. Fern stellar.

Fig. 6. Solid tabular crystal showing granulations.
" 7. Primative crystal.
" 8. Compound crystal.

METEOROLOGICAL STATISTICS FOR 1904.

BY F. H. LOUD.

The October number, 1904, of *Colorado College Studies,* issued under the title of "Semi-annual Bulletin of the Colorado College Observatory," contained a summary of the meteorological observations made at the College station in the first six months of that year, January to June. The present number is intended as an annual review; and, being the first of that character, is meant to be complete in itself, not requiring comparison with a predecessor in order to the understanding or use of its statistical contents. This requirement has necessitated the repetition of a portion of the matter previously published. The description of the instruments, however, in which the principles of their construction were sought to be explained in a popular manner, has been omitted from the present issue, and any reader desiring information of this nature is referred either to the October publication or to the catalogues of manufacturers.

Building, Equipment and Exposure of Instruments.

The Observatory building, erected in 1894, the gift of Henry R. Wolcott, Esq., of Denver, is in latitude 38 deg. 50 min. 44 sec., longitude 6 hr. 59 min. 16.5 sec., elevation about 6,040 feet. (All of these figures are obtained by reference to neighboring stations of U. S. surveys.)

The astronomical equipment consists of a four-inch equatorial telescope, given to the College by the donor of the building, and a transit instrument and clock, given in 1900 by Mr. Charles S. Blackman, of Montreal, Canada.

The meteorological equipment in part antedates the building, the nucleus having been obtained from the U. S. Signal

Service when the College first became a voluntary weather station in 1878. Several additions of apparatus were subsequently made. Much the most noteworthy, during the earlier years, was that of a set of Draper self-recording instruments, due to the generous interest of Dr. S. E. Solly, of Colorado Springs. Of these, the barograph alone remains in use. In November, 1904, the quadruple register with all the apparatus connected with it, together with a number of other instruments, especially hygrometers of different kinds, were given by General W. J. Palmer, who also provided funds for computation and publication.

The exposure of the instruments pertaining to wind, sunshine and temperature is on the roof of Hagerman Hall, a building standing east of the Observatory, and on higher ground. Here is the standard thermometer shelter, 10 feet above the roof, 54 feet above the ground, and 69.5 feet above the level of the Observatory floor. It contains maximum and minimum thermometers, a whirling psychrometer, and a Richard thermograph. Higher by 7 feet, and at horizontal distances of 11 feet from the shelter and 341 feet from the Observatory door, is the wind vane, on the iron support of which are attached the Robinson anemometer and the electric sunshine recorder. The cable connecting these three instruments with the quadruple register in the Observatory is laid underground.

Near the middle of the flat roof of the Observatory, which affords, on the east side of the dome, a clear space 37 feet long (east and west), and $28\frac{1}{2}$ feet broad, and is 16 feet above the ground, is the rain-gauge, provided with a tipping-bucket attachment for registration. It is electrically connected with the quadruple register, which is in the same building, on the first floor. Here, also, on the north side, is a window-shelter for the exposure of the hygrometric apparatus, exclusive of the whirled psychrometer. This consists of a

Richard registering psychrometer, a dew-point apparatus, and a hair hygrometer. The Draper barograph is on the south wall of the same room, but the barometer read at the tri-daily observations is in the upper story of Hagerman Hall, at an elevation exceeding that of the barograph by 43.2 feet.

THE DAILY RECORD AND MONTHLY SUMMARY.

From the automatic registers of the different instruments for each day, together with the tri-daily eye observations,—which, being simultaneous with those of the national weather service, occur at 6 a. m., 12 m. and 6 p. m., mountain time,—a sheet called the "Daily Record" is made up. A sample copy of this, being the record for October 24, is given on page 127. The first column gives the time of the ending of the hour, to the whole duration of which are referred the succeeding data on the same horizontal line, save only those of the barometer, which relate to the end of the hour. The four columns next following contain the count of the dots made at one-minute intervals by the four pens of the anemoscope, answering to the directions N., E., S., W. The next two columns, headed "Components, X," contain the difference between the north and south counts. The excess is placed in the first column when the larger of the two is north, in the second when it is south. In like manner, the two columns of components under "Y," are the differences between west and east, and when west prevails the former is used, when east, the latter. These components X and Y, being taken as the legs of a right triangle, the bearing or angle made with the meridian by the hypotenuse of the triangle, regarded as the mean direction of the wind, follows in the next pair of columns, being expressed in degrees and minutes. This bearing is taken from a table, constructed for the purpose. The next column contains the count of the anemometer record for the hour, showing the number of miles run by the wind. This "velocity record" is resolved, by means of a specially devised traverse table, in directions parallel and perpendicular to the meridian, and the result is contained in the four columns following, completing the space devoted in the table to the wind.

The next column contains the rainfall in hundredths of an inch, and the next the number of minutes of sunshine, both these being taken by direct counting from the quadruple register. From the indications of this instrument exclusively, all of the columns thus far mentioned, except the rainfall, are derived, and hence they contain no entries in the lines marked "Obs," which are intended for the eye observations. The rainfall, however, besides its instrumental register, claims a place in the line of "Obs," for the stick measurement, which shows the total amount fallen since the observation preceding. Of the columns pertaining to the barometer, on the other hand, the first three—"Height in Inches," "Attached Thermometer," "Temperature Correction," are appropriate to the eye observations alone, the Draper barograph being so adjusted that the temperature correction is made by the instrument. The column of "Pressure," therefore, contains in the "Observation" line the reduced indication of the barometer at Hagerman Hall, but in the hourly lines the readings of the Draper barograph; and it is to be noted that this is the reading at the end of the hour, not the mean for the whole hour preceding, as would be consistent with the remaining contents of the same line. Under "Temperature and Humidity," the entries in the lines of "Observation" are the readings of the maximum and minimum thermometers and of the whirled psychrometer, together with the relative humidity and dew point deduced from the latter by means of a table in which a constant pressure of 24 inches is assumed. The hourly lines under the same head contain data derived from the Richard thermograph, the column "Max." showing the highest temperature registered during the hour, "Min." the lowest, while under "Dry" is placed the mean of the numbers in the two preceding columns, fractions of a degree being neglected. The contents of the column of "Remarks" are in general miscellaneous, but the state of the weather, with the amount of clouds, expressed in tenths of the sky area, is usually entered with each eye observation, and the name of the observer is placed at the end of the line. All the entries in these "observation" lines are copied in red ink from the slip containing the original record, while the remaining entries on the page are in black ink.

The foregoing description of the construction of the Daily Record applies to the normal conditions of instrumental action. Exceptional cases arise, requiring a modification of the usual procedure. For instance, in the winter months it is not deemed safe to expose the mechanism of the recording rain-gauge to the dangers of freezing. Hence there is no hourly record of precipitation in this part of the year, but the total fall is obtained by stick measurement, and the times of beginning and ending by personal observation when practicable. In a few instances the Draper barograph has been out of commission, and its place supplied by the Richard instrument. The records of the quadruple register are not wholly complete. The defect has been rarely due to negligence, but sometimes to unexpected irregularities in the electrical or mechanical action of the apparatus, which has been promptly restored to working order. Only one department of this register has been troublesome to the extent of a serious gap in the record, viz: the sunshine-recorder. The delicate structure of this instrument which gives it important advantages over any other invention yet derived for its purpose, involves such a sensitiveness to thermometric conditions that its adjustment needs correction from time to time, otherwise it will either fail to record sunshine for a too long a time while the sun is low, or else it will continue to record after the sun has been obscured by cloud, or even by the Western hills. To entirely avoid both errors is admittedly impracticable; hence the manufacturer advises a correction of a certain percentage added to the instrumental record. While this method has been pursued in some compilations of the records of this observatory, the tables of the present publication include only the actual record of the instrument for the ten months in which it was deemed sufficiently correct. In July, however, it was found necessary to substitute the photographic sunshine-record kept at the Harvard station on Nob Hill; and in August, this substitute being unavailable, the sunshine column is omitted from the summaries, though a number of records of individual days are preserved at the Observatory.

The method of reducing the wind record may require a brief explanation. The count of the dots made by the four pens of the register in the course of an hour shows in how many minutes out of sixty the vane at the close of the minute was found pointing within 67½ degrees of a particular cardinal point. To treat this record of frequencies after the manner of the components of a force may appear to involve an unwarranted assumption. Thus, if the wind were to blow the whole hour, with no deviation from a point fifteen degrees east of north, records would be made by the north pen only, and the mean direction for the hour would be stated as due north. But the wind in its actual movement never shows a steadiness of this kind, but always oscillates back and forth about a mean direction. If the latter were 15° east of north, it is considered that a portion of the dots, in a ratio to those of the north pen differing little, probably, from that of the sine to the cosine of 15°, would prove to be made by the east pen; and if the ratio happened to be larger or smaller in an individual case, the error would ere long be cancelled by an equal deviation toward the opposite side. Another part of the reduction, in which a similar allowance is to be made, occurs when the mean direction, determined as above, is credited with the entire run of wind for the hour. If for the first thirty-one minutes a wind of six miles an hour were blowing from due north so that three mile-notches were produced in this time, and then it were followed for twenty-nine minutes by a due south wind at the rate of twelve miles an hour, making six notches, the mean direction for the hour, found from the excess of the number of dots, would be north, and the nine miles of wind movement would be set down as coming from this quarter. Here again it must be considered on the other hand that when a reversal of direction like this occurs (as sometimes, certainly, is the case), a mechanical integration of the wind's force takes place antecedently to the action on the anemometer, so that the amounts of wind registered from the opposing quarters are small, and the errors are reduced in the same proportion.

The "Monthly Summary of Instrumental Record," pages 128-151, is in the main made up from the sums and means of the "Daily Record." The first column, "Mean Temperature for Twenty-four Hours," is the mean of the column headed "Dry" in the thermometric division of the daily sheet. The "Extremes" are the readings of the maximum and minimum thermometers, and are hence independent of the thermograph, whose indications will, of course, frequently fall short of the limits of range. The "Hours of Extremes," on the other hand, are taken from the Richard instrument. The columns under "Psychrometer" are means, those under "Clouds at Observation" are sums, from the like columns in the foregoing sheets, hence the scale of cloudiness is here from 0 to 30. The "Number of Minutes Actual Sunshine" is another instance of summation. The "Possible Sunshine," in the next column, is the length of time the sun remains in sight each day, as determined, with careful allowance for the effect of the mountains in the west, in an article in "Colorado Weather," reprinted in the October bulletin. The ratio of the "actual" to the "possible" sunshine is shown in the column of "Percentage," where the numbers are lower than if the unrecorded morning sunshine were supplied by estimate, as is usual at other stations.

The column headed "Barometer, Actual Pressure at 12 M.," is from the eye observation at noon. The "Total Velocity of Wind" is from the sum of the hourly numbers in the Daily Record, checked by the dial-readings of the anemometer. Under the "Sum of Components" are given the footings of the four columns headed "Velocity Resolved" in the Daily Record. From these are deduced trigonometrically the "Equivalent" in direction and number of miles of resultant movement. Finally, under "Rain Gauge" are given the times of ending of the hours during which the first and last precipitation occurred, together with the total amount.

An annual summary by months is appended, page 152.

The care of the instruments and the regular tri-daily observations is committed to two student observers. These, for the year 1904, were Messrs. C. M. Angell and Fred. Hill. In the reduction of observations, the Director has been assisted by Mr. Chas. D. Child and Mr. David Mohler.

COLORADO COLLEGE METEOROLOGICAL RECORD, COLLEGE STATION.—DAILY RECORD FOR MONDAY, OCTOBER 24, 1904, MIDNIGHT TO MIDNIGHT, 105TH MERIDIAN TIME.

HOUR END'G	WIND.															Rainfall, 1/100 inch.	Sunshine, Min.	BAROMETER.				TEMP. AND HUMIDITY.							ATMOS.	OBS.
	DIRECTION.										VELOCITY.											THERMOMETERS.								
	Recorded.				Components.				Bearing		Record.	Resolved.						Height inches	Att. ther.	Temp're Cond.	Pressure.	Max.	Min.	Dry.	Wet.	Rel. Hu.	Abs. Hu.	Dew Pt.		
	N	E	S	W	X		Y		°	′		N	S	W	E															
1 a. m.	60	0	0	7	60		7		6	39	8	7.9		0.9							24.03	44	40	42						
2	60	0	0	45	60		45		36	52	11	8.8		6.6							.04	46	44	45						
3	60	0	0	57	60		57		43	32	8	5.8		5.5							.05	46	42	44						
4	60	5	0	35	60		30		26	34	26	23.2		11.6							.11	47	42	44						
5	60	1	0	41	60		40		33	41	25	20.8		13.9							.16	42	40	41						
6	60	2	0	20	60		18		16	42	18	17.2		5.2							.16	40	39	40						
Obs.																		24.236	56	.060	24.176	57	36	37	33	69		28	Cloudy 10	*Hill.*
7	60	10	0	1	60			9	8	32	16	15.8			2.4						.18	39	37	38						
8	60	15	0	2	60			13	12	14	22	21.6			4.6						.22	37	36	36						
9	60	6	0	4	60			2	1	55	18	18.0			0.6						.27	36	34	35						
10	60	4	0	4	60			0	0	0	15	15.0			0						.29	34	34	34						
11	60	1	0	12	60		11		10	23	15	14.8		2.7							.29	33	32	32						
12	60	2	0	7	60		5		4	46	12	12.0		1.0							.28	33	32	32						
Obs.																T		24.350	69	.089	24.261	57	33	34	31	74		27	Cloudy 10	*Hill.*
1 p. m.	60	12	0	5	60			7	6	39	17	16.9			2.0						.26	34	33	34						
2	60	2	0	10	60		8		7	36	11	10.9		1.5							.26	35	34	34						
3	60	5	0	6	60		1		0	57	10	10.0		0.2							.27	34	34	34						
4	60	1	0	14	60		13		12	14	8	7.8		1.7							.27	34	34	34						
5	60	0	0	33	60		33		28	49	4	3.5		1.9							.27	34	34	34						
6	42	0	0	60	42		60		55	00	2	1.1		1.6							.28	34	34	34						
Obs.																		24.360	74	.100	24.260	48	33	36	31	60		24	Cloudy 10	*Angell.*
7	0	0	0	60	0		60		90	0	3	0		3.0							.28	35	35	35						
8	0	0	0	60	0		60		90	0	3	0		3.0							.29	35	35	35						
9	13	13	0	47	13		34		69	05	2	0.7		1.9							.30	35	35	35						
10	20	60	2	0	18			60	73	18	11	3.2			10.5						.31	35	32	34						
11	5	50	28	0		23		50	65	18	6		2.5		5.5						.34	32	31	32						
12	0	60	49	0		49		60	50	46	3		1.9		2.3						.34	31	31	31						
Sums.											274	235.0	4.4	62.2	27.9		0							869						
Means											11.4													36.2						

MONTHLY SUMMARY OF

JANUARY,

DATE.	THERMOMETERS.					PSYCHROMETER.						SUNSHINE REC[illegible]		
	Temperatures.			Hours of Extremes.		Relative Humidity.			Dew-point.			Clouds at Observ'n.	Number Minut[illegible]	
	Mean of 24 h.	Extremes. Max.	Min.	Max.	Min.	6 AM	12 M.	6 PM	6 AM	12 M.	6 PM		Act-ual.	Pos-sible
1	26.0	44	17	1 p.m.	8 a.m.	73	32	67	11	15	17	17	447	529
2	20.5	24	16	1 p.m.	12 p.m.	87	76	87	17	16	17	28	146	529
3	21.3	29	10	11 a.m.	12 p.m.	88	67	79	21	17	14	16	386	530
4	20.4	41	11	2 p.m.	3 a.m.	67	23	50	6	8	14	5	436	531
5	25.0	39	15	1 p.m.	2 a.m.	72	24	48	11	6	11	14	367	532
6	22.8	38	11	3 p.m.	7 a.m.	84	64	67	12	23	17	1	469	533
7	34.9	53	18	3 p.m.	5 a.m.	72	11	25	11	2	1	0	498	533
8	36.0	55	23	1 p.m.	4 a.m.	59	13	23	8	8	3	0	500	534
9	36.0	49	27	10 a.m.	12 p.m.	56	1	13	20	-28	6	11	379	535
10	27.0	38	8	3 p.m.	8 a.m.	45	29	36	-4	6	9	4	458	535
11	31.5	41	23	3 a.m.	8 p.m.	71	72	78	22	25	21	24	201	536
12	34.0	44	21	12 p.m.	3 a.m.	54	48	28	11	17	11	12	311	537
13	44.9	62	20	12 m.	6 a.m.	54	7	7	11	1	-4	6	512	538
14	37.3	53	21	3 p.m.	7 a.m.	55	17	31	12	7	8	5	494	540
15	39.9	52	20	12 m.	12 p.m.	40	11	39	21	2	16	2	443	541
16	39.3	60	17	2 p.m.	6 a.m.	76	3	10	5	-20	1	3	491	54[illegible]
17	......	.....	21	....	6 a.m.	39	21	33	3	8	10	6	423	54[illegible]
18	......	55	24	3 p.m.	....	34	14	14	19	8	4	.....	491	54[illegible]
19	28.8	40	16	1 a.m.	11 p.m.	50	31	57	14	8	15	0	488	54[illegible]
20	22.3	35	10	3 p.m.	7 a.m.	89	70	52	10	21	16	2	409	54[illegible]
21	21.6	32	10	12 m.	6 a.m.	90	44	47	12	14	10	7	335	55[illegible]
22	17.6	30	6	4 p.m.	8 a.m.	41	52	87	-8	10	18	20	0	55[illegible]
23	16.0	29	1	11 p.m.	6 a.m.	86	48	72	2	5	16	2	488	55[illegible]
24	30.8	44	16	1 p.m.	3 a.m.	63	11	17	12	-4	0	7	475	55[illegible]
25	15.6	26	3	1 a.m.	12 p.m.	56	49	82	5	7	8	6	451	55[illegible]
26	20.2	35	3	2 p.m.	1 a.m.	72	29	38	11	6	7	2	422	55[illegible]
27	17.4	27	3	11 a.m.	7 a.m.	77	26	34	0	0	0	11	377	56[illegible]
28	14.3	25	-1	3 p.m.	8 a.m.	8	10	48	.....	19	5	0	507	56[illegible]
29	28.2	40	15	2 p.m.	6 a.m.	56	29	25	5	9	5	17	499	56[illegible]
30	26.9	35	16	11 a.m.	12 p.m.	32	78	87	6	21	19	27	162	56[illegible]
31	20.8	38	8	4 p.m.	4 a.m.	88	50	64	6	14	13	3	518	56[illegible]
Sums.	......	.....	.....	....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Means.	26.8	40.4	13.8	....	....	62	34	47	10	7	10	.....	.....	.....
Perctg.	......	.....	.....	....	....	.....	.....	.....	.....	.....	.....	29%	.....	.....

INSTRUMENTAL RECORD.

1904.

...om. ...al ...ure ...M.	Anemometer and Anemoscope. Wind. Total Velocity.	Sum of Components. N.	S.	W.	E.	Equivalent. Direction.	Miles.	Rain Gauge. Hours of Fall. Earliest.	Latest.	Total Amount.	Date.
42	240	221.9	1.7	46.9	15.0	N. 8° 15′ W.	222.5	0	0	0	1
22	111	9.3	68.3	4.8	69.3	S. 47° 33′ E.	87.4	0	0	T	2
32	217	191.3	6.3	21.1	34.1	N. 4° 01′ E.	185.5	0	0	0	3
49	147	75.3	50.4	16.5	47.5	N. 51° 24′ E.	39.9	0	0	0	4
53	189	175.6	3.3	20.5	26.7	N. 2° 04′ E.	172.4	0	0	0	5
07	139	94.6	31.9	15.9	27.9	N. 9° 22′ E.	73.7	0	0	0	6
78	161	126.5	21.4	22.3	20.4	N. 1° 02′ W.	105.1	0	0	0	7
76	181	147.5	21.1	21.7	20.9	N. 0° 22′ W.	126.4	0	0	0	8
52	476	319.0	0	337.1	0	N. 46° 35′ W.	464.1	0	0	0	9
55	155	94.1	18.3	63.3	25.8	N. 26° 19′ W.	84.6	0	0	0	10
02	242	203.6	14.2	34.1	41.6	N. 2° 16′ E.	189.6	0	0	0	11
35	333	194.9	17.7	190.2	40.8	N. 40° 08′ W.	231.8	0	0	0	12
53	355	181.9	30.3	239.1	30.6	N. 53° 59′ W.	257.8	0	0	0	13
21	121	89.4	20.4	24.9	14.1	N. 8° 54′ W.	69.8	0	0	0	14
45	226	......	......	......	......	....	......	0	0	0	15
41	216	125.1	18.6	97.6	38.0	N. 29° 14′ W.	122.0	0	0	0	16
90	139	......	......	......	......	....	......	0	0	0	17
63	362	......	......	......	......	....	......	0	0	0	18
12	204	32.4	104.6	6.4	129.4	S. 59° 35′ E.	142.6	0	0	0	19
90	151	116.4	22.3	24.3	24.4	N. 0° 04′ E.	94.1	0	0	T	20
34	162	103.1	12.8	51.7	41.3	N. 6° 34′ W.	90.9	0	0	0	21
25	168	126.8	16.5	59.9	15.5	N. 21° 56′ W.	118.9	0	0	T	22
25	167	69.0	61.1	29.0	57.9	N. 74° 43′ E.	30.0	—	-	.03	23
33	258	115.0	20.6	169.0	20.1	N. 57° 38′ W.	176.3	0	0	0	24
07	255	......	......	......	......	....	......	0	0	T	25
55	207	106.2	43.9	90.0	27.0	N. 45° 19′ W.	88.6	0	0	T	26
28	180	164.1	4.9	21.1	17.9	N. 1° 09′ W.	159.2	0	0	T	27
1	131	91.1	20.5	10.5	31.6	N. 16° 38′ E.	73.7	0	0	T	28
6	267	148.3	9.6	185.1	12.1	N. 51° 17′ W.	221.7	0	0	0	29
5	370	307.5	0	186.3	0.5	N. 31° 09′ W.	359.2	—	5 p.m.	.08	30
7	119	98.1	0.9	26.4	21.7	N. 2° 46′ W.	97.3	....	0	0	31
..	6649	3728.0	641.6	2015.5	852.1	....	......	....	....	.11	......
9	......	......	......	......	......	....	......	....	....	....	......
..	......	......	......	......	......	....	......	....	....	....	......

MONTHLY SUMMARY OF

FEBRUARY,

Date.	Thermometers. Temperatures. Mean of 24 h.	Extremes. Max.	Extremes. Min.	Hours of Extremes. Max.	Hours of Extremes. Min.	Psychrometer. Relative Humidity. 6 A.M.	12 M.	6 P.M.	Dew-point. 6 A.M.	12 M.	6 P.M.	Sunshine Rec[ord] Clouds at Observ'n.	Number [of] Minut[es] Actual.	Possible
1	40.1	54	20	1 p.m.	2 a.m.	38	17	10	11	11	-2	2	539	576
2	27.6	43	15	9 p.m.	6 a.m.	70	60	38	9	18	11	4	499	572
3	26.1	34	15	5 p.m.	6 a.m.	73	52	48	14	16	11	2	518	574
4	42.4	60	19	5 p.m.	1 a.m.	61	15	23	20	11	14	8	542	576
5	47.9	60	35	1 p.m.	5 a.m.	34	10	13	15	4	5	4	552	578
6	35.6	48	20	1 a.m.	12 p.m.	23	19	21	8	3	1	10	546	581
7	27.2	40	17	4 p.m.	2 a.m.	41	24	31	-8	6	8	5	477	58
8	20.9	30	12	3 p.m.	12 p.m.	89	49	52	12	13	10	10	444	58
9	21.1	35	6	3 p.m.	6 a.m.	58	49	50	1	13	14	18	519	58
10	16.9	30	-1	3 p.m.	6 a.m.	83	56	54	3	14	11	2	545	59
11	32.0	52	10	2 p.m.	2 a.m.	65	27	44	3	18	21	4	499	59
12	44.2	62	24	3 p.m.	3 a.m.	58	14	14	22	8	8	8	508	59
13	50.1	59	27	11 a.m.	12 p.m.	14	20	33	8	18	20	7	505	59
14	26.8	37	15	3 p.m.	6 a.m.	43	33	53	6	10	18	7	527	59
15	......	62	20	....	12 p.m.	51	14	32	25	18	15	9	576	59
16	33.0	65	17	3 p.m.	3 a.m.	33	20	34	4	13	17	13	439	60
17	29.9	39	24	3 a.m.	10 p.m.	81	71	89	26	22	22	30	213	60
18	23.7	31	14	2 p.m.	3 a.m.	85	62	77	14	21	20	7	403	60
19	23.4	34	11	2 p.m.	4 a.m.	85	62	79	8	21	23	16	527	61
20	31.8	46	19	1 p.m.	1 a.m.	49	21	27	13	9	7	7	438	61
21	23.2	30	16	4 p.m.	2 a.m.	86	75	59	16	17	17	22	133	61
22	52.6	66	29	4 p.m.	1 a.m.	24	30	28	16	25	25	14	369	61
23	54.3	62	43	5 p.m.	12 p.m.	28	22	28	20	20	25	11	595	6
24	44.9	64	27	8 p.m.	8 a.m.	73	49	31	24	28	27	14	577	6
25	59.9	69	40	12 m.	12 p.m.	32	11	12	33	11	13	13	421	6
26	42.4	58	28	4 p.m.	6 a.m.	52	32	41	16	24	26	11	457	6
27	55.5	71	41	4 p.m.	1 a.m.	14	16	15	11	19	16	8	.....	6
28	42.5	60	30	1 p.m.	7 a.m.	27	11	24	7	11	14	5	489	6
29	......	58	24	....	7 a.m.	65	41	8	15	21	-2	2	564	6
....	......	....	....	....	....	....	....	....	....	....	....	....	.....	..
....	......	....	....	....	....	....	....	....	....	....	....	....	.....	..
Sums,	......	....	....	....	....	....	....	....	....	....	....	....	.....	..
Means,	36.1	50.3	21.3	....	....	53	34	37	13	15	14	....	.....	..
Perctg.	......	....	....	....	....	....	....	....	....	....	....	31%	.....	..

INSTRUMENTAL RECORD.

1904.

Anemometer and Anemoscope.							Rain Gauge.			Date.
Wind.							Hours of Fall.		Total Amount.	
Total Velocity.	Sum of Components.				Equivalent.		Earliest.	Latest.		
	N.	S.	W.	E.	Direction.	Miles.				
380	200.4	23.3	229.1	48.0	N. 45° 38′ W.	253.3	0	0	0	1
159	45.4	65.6	41.4	61.1	S. 44° 17′ E.	28.2	0	0	T	2
171	83.2	65.7	20.7	69.1	N. 70° 07′ E.	51.4	0	0	0	3
148	78.6	44.7	16.4	46.3	N. 41° 25′ E.	45.2	....	....	0	4
331	46.1	167.7	209.5	2.5	S. 59° 34′ W.	240.1	0	0	0	5
376	79.6	82.8	311.1	4.8	S. 89° 24′ W.	306.3	0	0	0	6
167	54.2	51.3	103.7	3.0	N. 88° 21′ W.	100.7	0	0	0	7
147	68.7	53.1	11.3	58.3	N. 71° 38′ E.	49.5	0	0	0	8
121	43.2	47.5	7.9	59.6	S. 85° 14′ E.	51.9	0	0	T	9
189	54.2	85.5	9.2	98.3	S. 70° 39′ E.	94.4	0	0	T	10
153	83.2	46.5	20.3	45.2	N. 34° 09′ E.	44.4	0	0	0	11
127	63.9	30.7	24.2	35.7	N. 19° 06′ E.	35.1	0	0	0	12
537	170.1	23.0	467.8	7.8	N. 72° 16′ W.	483.0	0	0	0	13
205	41.3	99.8	10.7	123.6	S. 62° 37′ E.	127.2	0	0	0	14
226	114.0	66.0	63.9	54.3	N. 11° 19′ W.	48.6	0	0	0	15
121	58.2	33.0	11.8	48.5	N. 55° 32′ E.	44.5	0	0	0	16
373	369.3	0	14.9	21.5	N. 1° 01′ E.	369.4	0	0	0	17
145	53.2	56.5	20.3	63.1	S. 85° 35′ E.	42.9	....	....	.10	18
143	70.2	47.8	10.6	50.2	N. 60° 31′ E.	45.5	....	....	.09	19
173	135.6	19.5	13.0	41.0	N. 13° 34′ E.	119.4	0	0	0	20
106	17.8	60.5	5.2	50.0	S. 46° 23′ E.	61.9	0	0	T	21
446	119.8	86.2	322.1	36.7	N. 83° 17′ W.	287.4	0	0	0	22
342	42.6	96.6	286.8	11.8	S. 78° 54′ W.	280.2	0	0	0	23
142	24.8	56.2	27.1	79.6	S. 59° 07′ E.	61.2	0	0	0	24
......	......	......	......	......	....	......	0	0	0	25
......	......	......	......	......	....	......	0	0	0	26
......	......	......	......	......	....	......	0	0	0	27
221	94.5	79.5	88.8	25.9	N. 76° 35′ W.	64.7	0	0	0	28
136	54.1	42.4	23.7	59.5	N. 71° 54′ E.	37.7	0	0	T	29
......	......	......	......	......	....	......	......	......	......	......
......	......	......	......	......	....	......	......	......	......	......
5785	2266.2	1531.4	2371.5	1205.4	....	......	......	......	.19	......
......	......	......	......	......	....	......	......	......	......	......
......	......	......	......	......	....	......	......	......	......	......

MONTHLY SUMMARY OF

MARCH,

Date.	Thermometers. Temperatures. Mean of 24 h.	Extremes. Max.	Extremes. Min.	Hours of Extremes. Max.	Hours of Extremes. Min.	Psychrometer. Relative Humidity. 6 A.M.	12 M.	6 P.M.	Dew-point. 6 A.M.	12 M.	6 P.M.	Sunshine Re[cord] Clouds at Observ'n.	Numbe[r of] Minu[tes] Actual.	Po-sibl[e]
1	49.5	66	31	4 p.m.	7 a.m.	33	12	11	10	11	8	7	595	64
2	43.8	69	18	2 p.m.	11 p.m.	14	13	67	10	14	17	15	515	64
3	23.9	39	10	4 p.m.	7 a.m.	62	44	33	0	14	10	8	596	64
4	......	65	25	....	1 a.m.	59	12	15	23	11	11	23	439	64
5	33.0	42	22	4 p.m.	12 p.m.	54	17	36	19	0	17	6	605	64
6	40.2	60	21	4 p.m.	4 a.m.	43	17	30	6	14	21	13	542	65
7	47.4	61	33	3 p.m.	2 a.m.	40	20	25	18	20	20	16	530	65
8	43.7	60	26	3 p.m.	5 a.m.	41	37	32	10	28	24	18	592	65
9	44.0	56	31	1 a.m.	12 p.m.	38	6	19	26	-12	3	11	585	66
10	38.0	49	23	4 p.m.	7 a.m.	59	17	14	8	4	4	9	622	66
11	49.0	64	32	3 p.m.	3 a.m.	44	19	7	18	18	-4	9	563	66
12	33.2	51	22	1 a.m.	12 p.m.	39	82	79	13	30	24	24	269	66
13	32.4	46	16	4 p.m.	7 a.m.	72	56	8	11	20	-7	3	636	66
14	33.4	51	30	3 p.m.	12 p.m.	46	55	26	15	30	14	9	448	67
15	41.8	56	26	2 p.m.	5 a.m.	30	19	40	4	13	27	16	475	67
16	33.0	39	31	1 a.m.	6 a.m.	81	75	100	26	29	32	28	153	6
17	41.9	52	25	2 p.m.	6 a.m.	89	27	26	26	18	20	14	597	6
18	52.6	65	37	5 p.m.	6 a.m.	28	22	37	16	20	34	22	616	6
19	41.3	51	32	1 a.m.	7 a.m.	72	60	39	25	30	23	11	629	6
20	42.1	62	26	2 p.m.	5 a.m.	79	28	30	22	25	21	9	391	6
21	32.1	45	22	1 a.m.	12 p.m.	52	63	66	16	22	25	18	254	6
22	35.1	51	15	3 p.m.	6 a.m.	94	26	29	14	14	14	6	557	6
23	44.7	59	25	12 m.	6 a.m.	67	22	25	17	18	18	26	521	6
24	40.0	46	32	4 p.m.	10 p.m.	49	11	21	22	-4	8	7	487	6
25	27.5	35	17	2 p.m.	12 p.m.	56	33	79	14	10	22	14	404	6
26	25.5	42	6	5 p.m.	6 a.m.	91	49	27	4	19	12	14	334	7
27	31.2	41	22	5 p.m.	5 a.m.	63	81	42	12	26	19	29	549	7
28	46.7	62	26	1 p.m.	3 a.m.	49	24	38	19	24	32	10	645	7
29	46.7	63	33	1 p.m.	5 a.m.	33	28	25	10	25	20	7	635	7
30	43.8	56	32	1 p.m.	6 a.m.	74	23	39	27	18	23	16	527	7
31	35.6	40	31	4 p.m.	12 p.m.	75	75	76	29	29	31	3	334	[illegible]
Sums,	......	......	......	....	....	......	......	......	......	......	......	......	......	..
Means,	39.1	53.1	25.1	....	....	56	35	37	16	17	16	......	......	..
Perctg.	......	......	......	....	....	......	......	......	......	......	......	45%	......	

INSTRUMENTAL RECORD.

1904.

BAROM.	ANEMOMETER AND ANEMOSCOPE.							RAIN GAUGE.			DATE.
	WIND.							Hours of Fall.		Total Amount.	
Actual Pressure at 2 P.M.	Total Velocity.	Sum of Components.				Equivalent.					
		N.	S.	W.	E.	Direction.	Miles.	Earliest.	Latest.		
.947	246	68.7	79.5	91.8	60.3	S. 71° 05′ W.	33.3	0	0	0	1
.791	724	328.5	51.8	432.9	25.6	N. 55° 49′ W.	492.5	0	0	0	2
.301	208	48.4	112.0	3.2	112.3	S. 59° 46′ E.	126.3	0	0	0	3
.795	248	142.8	34.5	100.5	33.4	N. 31° 47′ W.	127.4	0	0	0	4
.103	440	382.6	0	139.5	41.2	N. 14° 25′ W.	395.0	0	0	0	5
.039	137	84.4	26.3	16.6	34.0	N. 16° 40′ E.	60.7	0	0	0	6
.981	130	76.9	32.5	21.9	34.8	N. 16° 12′ E.	46.2	0	0	0	7
.797	185	57.8	81.4	14.8	88.2	S. 72° 11′ E.	77.1	0	0	0	8
.438	576	138.1	93.1	476.1	10.8	N. 84° 28′ W.	467.5	0	0	T	9
.851	322	83.5	172.9	21.0	150.0	S. 55° 17′ E.	157.0	0	0	0	10
.753	212	48.2	119.8	87.1	23.7	S. 41° 32′ W.	95.7	0	0	0	11
.918	181	62.6	54.5	66.7	53.5	N. 58° 28′ W.	15.5	......	....	.02	12
.072	179	72.8	32.3	67.5	62.8	N. 6° 37′ W.	40.7	0	0	0	13
.957	204	25.4	111.6	18.7	116.1	S. 48° 30′ E.	130.1	0	0	0	14
.855	206	105.6	56.1	69.9	33.8	N. 36° 06′ W.	61.3	0	0	0	15
.009	204	151.6	29.6	6.0	46.9	N. 18° 32′ E.	128.7	....	....	.05	16
.114	174	35.9	96.2	28.8	71.7	S. 35° 26′ E.	74.0	....	....	.03	17
.905	175	80.6	42.0	77.6	37.1	N. 46° 23′ W.	56.0	0	0	0	18
.932	271	15.7	148.5	36.9	167.3	S. 44° 29′ E.	186.1	0	0	0	19
.471	310	78.4	125.6	173.0	34.0	S. 71° 15′ W.	146.8	5 p.m.	5 p.m.	.02	20
.697	207	97.0	63.3	30.8	68.3	N. 48° 04′ E.	50.4	12 m.	12 m.	.01	21
.965	172	48.0	86.9	45.8	38.5	S. 10° 38′ W.	39.6	0	0	0	22
.656	323	34.2	221.0	134.9	35.0	S. 28° 08′ W.	211.9	0	0	0	23
.664	347	134.8	92.1	209.5	22.7	N. 77° 08′ W.	191.7	0	0	0	24
.867	285	45.4	180.9	8.7	149.7	S. 46° 09′ E.	195.6	0	0	0	25
.117	143	64.1	39.2	11.6	74.3	N. 68° 21′ E.	67.5	....	....	.02	26
.240	154	41.6	80.0	4.2	73.6	S. 61° 03′ E.	79.3	....	....	.05	27
.753	233	90.9	37.3	138.5	29.2	N. 63° 53′ W.	121.8	0	0	0	28
.498	239	121.3	26.3	133.4	22.7	N. 49° 22′ W.	145.9	0	0	0	29
.556	175	80.8	47.4	65.2	30.2	N. 46° 20′ W.	48.3	....	....	.20	30
.955	241	191.5	0	121.9	1.2	N. 32° 13′ W.	226.4	1 a.m.	10 p.m.	.20	31
....	7852	3038.1	2374.6	2865.0	1782.9	....	......	....	....	.60	......
.871	......	......	......	......	......	....	......	....	....	......	......
......	......	......	......	......	......	....	......	....	....	......	......

MONTHLY SUMMARY OF

APRIL,

DATE.	THERMOMETERS.					PSYCHROMETER.						SUNSHINE RECO[RD]		
	Temperatures.			Hours of Extremes.		Relative Humidity.			Dew-point.			Clouds at Observ'n.	Number o[f] Minutes.	
	Mean of 24 h.	Extremes. Max.	Min.	Max.	Min.	6 AM	12 M.	6 PM	6 AM	12 M.	6 PM		Actual.	Possible.
1	29.4	33	26	5 p.m.	11 p.m.	89	81	82	26	26	28	27	308	721
2	36.4	49	23	3 p.m.	5 a.m.	89	85	61	22	30	31	6	653	725
3	39.8	54	33	6 p.m.	7 a.m.	95	77	48	33	32	31	17	329	728
4	41.9	57	33	2 p.m.	2 a.m.	61	49	51	25	37	30	16	356	730
5	44.1	54	33	5 p.m.	2 a.m.	57	42	77	27	28	46	4	692	733
6	44.9	61	33	2 p.m.	5 a.m.	59	18	31	23	16	20	8	.....	736
7	34.3	43	26	3 p.m.	7 a.m.	79	19	9	22	5	10	12	.....	739
8	32.2	43	35	3 p.m.	5 a.m.	45	28	73	8	11	26	16	242	742
9	40.3	59	20	4 p.m.	5 a.m.	75	25	16	17	18	11	1	718	744
10	57.6	73	38	3 p.m.	1 a.m.	19	12	18	11	15	21	13	681	748
11	50.9	59	42	4 p.m.	6 a.m.	46	30	26	24	25	33	17	643	752
12	46.7	64	27	5 p.m.	6 a.m.	70	19	18	21	18	16	0	706	754
13	57.5	71	37	3 p.m.	4 a.m.	24	9	21	16	10	27	13	554	756
14	56.6	71	37	12 m.	5 a.m.	40	13	19	21	18	23	18	550	759
15	36.1	52	24	1 a.m.	12 p.m.	70	54	61	29	23	20	24	14	762
16	31.1	44	15	5 p.m.	6 a.m.	72	43	31	11	16	16	12	602	764
17	47.0	59	22	5 p.m.	2 a.m.	61	31	34	25	27	30	17	510	767
18	50.6	65	32	5 p.m.	6 a.m.	52	20	10	21	20	4	7	635	769
19	54.8	71	37	1 p.m.	4 a.m.	72	1	15	34	–15	19	21	533	771
20	60.9	73	46	4 p.m.	11 p.m.	38	15	31	26	19	32	5	640	773
21	44.8	53	41	12 m.	9 p.m.	86	33	13	39	20	–1	22	422	776
22	53.0	67	42	5 p.m.	5 a.m.	19	10	11	6	4	11	0	732	779
23	51.0	63	35	2 p.m	4 a.m.	42	12	18	19	–2	16	16	551	782
24	39.3	44	30	1 p.m.	6 a.m.	100	66	60	32	32	30	24	386	785
25	47.5	55	33	2 p.m.	6 a.m.	67	7	45	26	1	30	11	579	788
26	45.0	54	35	6 p.m.	9 a.m.	63	60	46	28	30	32	22	402	791
27	53.8	70	32	4 p.m.	6 a.m.	91	17	22	32	24	29	23	548	794
28	59.2	72	40	2 p.m.	6 a.m.	73	9	17	36	10	21	10	556	796
29	48.5	52	43	2 p.m.	7 p.m.	41	49	68	26	32	36	21	331	799
30	45.2	52	38	11 a.m.	4 a.m.	77	48	74	33	31	38	23	296	800
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Sums,	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Means,	46.0	57.9	32.6	.....	.....	62	33	37	24	19	24	.....	.....	.....
Perctg.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	17%		

INSTRUMENTAL RECORD.

1904.

ROM.	ANEMOMETER AND ANEMOSCOPE.							RAIN GAUGE.			Date.
	WIND.							Hours of Fall.		Total Amount.	
ual sure 2 M.	Total Velocity.	Sum of Components.				Equivalent.		Earliest.	Latest.		
		N.	S.	W.	E.	Direction.	Miles.				
.324	175	58.6	82.0	7.6	79.2	S. 71° 54′ W.	75.3	1 a.m.	12 m.	.15	1
.207	165	45.2	90.8	4.5	71.9	S. 55° 55′ E.	81.3	0	0	0	2
.140	134	35.4	63.8	29.3	47.1	S. 32° 05′ E.	33.5	1 a.m.	8 a.m.	.02	3
.003	170	105.4	15.9	89.0	3.4	N. 43° 43′ W.	123.8	0	0	0	4
.232	236	......	......	......	......	....	......	0	0	0	5
766	342	......	......	......	......	....	......	0	0	0	6
105	398	340.1	0	136.0	15.9	N. 19° 27′ W.	360.7	0	0	0	7
088	371	344.3	0	24.7	67.8	N. 7° 08′ E.	347.0	0	0	0	8
206	115	45.1	52.8	17.9	23.9	S. 37° 56′ E.	9.7	0	0	0	9
980	222	131.2	5.4	118.9	12.0	N. 40° 21′ W.	165.1	0	0	0	10
126	213	147.7	20.2	25.4	67.8	N. 18° 24′ E.	134.3	0	0	0	11
203	119	37.7	52.4	3.0	59.3	S. 75° 22′ E.	58.1	0	0	0	12
015	171	72.8	39.4	56.7	37.7	N. 29° 38′ W.	38.4	0	0	0	13
393	262	152.2	0	176.5	5.6	N. 48° 19′ W.	228.9	0	0	0	14
117	301	156.6	49.6	15.9	142.6	N. 49° 49′ E.	165.8	0	0	0	15
066	336	3.0	234.8	0	234.4	S. 45° 19′ E.	329.7	0	0	T	16
000	183	51.9	91.2	17.5	83.6	S. 59° 16′ E.	76.9	0	0	0	17
075	252	51.6	143.2	19.0	131.9	S. 50° 57′ E.	145.4	0	0	0	18
371	219	69.7	59.0	135.7	23.0	N. 84° 34′ W.	113.1	0	0	0	19
76	269	24.4	168.0	36.7	124.8	S. 31° 32′ E.	168.5	0	0	0	20
15	648	233.8	57.2	501.0	59.5	N. 68° 12′ W.	475.5	0	0	0	21
82	380	77.7	78.5	268.0	52.8	S. 89° 47′ W.	213.4	0	0	0	22
14	386	160.9	159.9	143.2	11.6	N. 89° 34′ W.	131.9	0	0	0	23
07	690	......	......	......	......	....	......	4 a.m.	10 a.m.	.03	24
59	202	43.4	93.6	39.1	101.0	S. 50° 58′ E.	79.7	0	0	0	25
70	168	6.8	119.1	9.0	90.1	S. 35° 50′ E.	138.5	0	0	0	26
85	179	36.3	93.3	5.0	99.4	S. 58° 53′ E.	110.3	0	0	0	27
65	256	36.8	184.4	46.2	46.6	S. 0° 09′ E.	150.2	0	0	0	28
82	433	364.3	4.8	152.5	20.0	N. 20° 14′ W.	383.2	7 p.m.	7 p.m.	.03	29
64	201	153.9	0	38.8	18.9	N. 7° 22′ W.	155.2	0	0	0	30
...	......	......	......	......	......	....	......	....	....	......	......
...	8196	2986.8	1859.3	2117.1	1751.8	....	......	....	....	.23	......
2336	......	......	......	......	......	....	......	....	....	......	......
...	......	......	......	......	......	....	......	....	....	......	......

MONTHLY SUMMARY OF

MAY,

Date.	Thermometers.					Psychrometer.						Sunshine Rec		
	Temperatures.			Hours of Extremes.		Relative Humidity.			Dew-point.			Clouds at Observ'n.	Number Minute	
	Mean of 24 h.	Extremes. Max.	Extremes. Min.	Max.	Min.	6 AM	12 M.	6 PM	6 AM	12 M.	6 PM		Actual.	Possible
1	45.2	54	33	4 p.m.	5 a.m.	92	54	80	34	34	40	30	285	802
2	41.0	44	36	3 a.m.	6 p.m.	97	100	92	41	44	35	27	0	804
3	44.0	52	37	5 p.m.	6 a.m.	85	49	69	34	32	37	14	556	807
4	44.1	54	34	1 p.m.	5 a.m.	85	51	64	34	36	37	23	487	808
5	52.0	63	40	2 p.m.	2 a.m.	48	28	46	31	27	36	19	495	810
6	55.6	72	38	4 p.m.	5 a.m.	47	27	21	25	29	27	11	733	813
7	50.0	57	40	3 p.m.	11 p.m.	56	93	42	38	44	28	23	348	816
8	41.5	48	33	4 p.m.	4 a.m.	49	40	40	22	25	25	3	724	819
9	46.7	62	30	4 p.m.	5 a.m.	75	38	20	29	29	20	1	725	822
10	59.0	73	38	3 p.m.	3 a.m.	46	11	12	28	15	15	18	623	824
11	55.5	63	46	5 p.m.	5 a.m.	47	24	29	29	24	29	8	717	827
12	43.8	49	37	1 a.m.	5 a.m.	77	60	55	32	30	30	22	338	82
13	44.3	53	34	5 p.m.	6 a.m.	75	46	40	28	28	27	11	586	83
14	53.5	68	36	5 p.m.	6 a.m.	76	33	52	30	35	47	19	640	83
15	54.2	63	46	10 a.m.	12 p.m.	52	30	38	37	30	32	21	570	83
16	46.9	51	41	11 a.m.	12 p.m.	63	93	70	35	40	39	27	124	83
17	51.2	61	37	3 p.m.	4 a.m.	72	50	46	34	38	37	10	690	83
18	59.5	72	40	4 p.m.	5 a.m.	74	14	29	38	25	34	11	659	83
19	61.1	76	44	3 p.m.	5 a.m.	49	27	52	32	37	47	19	605	83
20	58.0	65	54	11 a.m.	6 a.m.	57	52	74	40	47	49	20	337	84
21	55.2	66	49	2 p.m.	7 a.m.	82	62	55	45	48	41	20	494	84
22	61.0	72	45	5 p.m.	5 a.m.	71	58	30	42	54	34	4	675	84
23	59.5	70	47	4 p.m.	3 a.m.	71	39	40	42	42	43	9	672	84
24	62.8	78	48	3 p.m.	5 a.m.	88	14	21	49	24	27	15	594	84
25	54.7	59	45	1 a.m.	11 p.m.	81	94	75	42	50	40	29	390	84
26	44.6	49	41	4 p.m.	6 a.m.	93	87	93	39	42	42	30	120	84
27	49.8	59	42	6 p.m.	5 a.m.	100	78	79	42	47	50	20	397	85
28	55.9	64	48	1 p.m.	3 a.m.	76	32	33	43	31	33	15	655	85
29	60.9	71	44	4 p.m.	3 a.m.	56	21	22	37	27	29	5	805	85
30	62.4	74	44	2 p.m.	6 a.m.	65	23	22	39	33	31	15	741	85
31	58.5	72	48	11 a.m.	12 p.m.	57	45	45	40	41	39	14	751	85
Sums.	......	.....	.....	....	....	.....	.....	.....	.....	.....	.....	.....	.....	...
Means.	52.7	62.4	41.1	....	....	70	48	48	36	35	35	.....	.....	...
Perctg.	......	.....	.....	....	....	.....	.....	.....	.....	.....	.....	54%	.....	...

INSTRUMENTAL RECORD.

1904.

...OM.	ANEMOMETER AND ANEMOSCOPE.							RAIN GAUGE.			DATE.
	WIND.							Hours of Fall.		Total Amount.	
...ual ...ure ... M.	Total Velocity.	Sum of Components.				Equivalent.		Earliest.	Latest.		
		N.	S.	W.	E.	Direction.	Miles.				
958	277	20.6	206.7	10.0	131.0	S. 33° 02′ E.	222.0	6 p.m.	10 p.m.	.03	1
777	434	45.5	200.7	17.6	319.3	S. 62° 47′ E.	339.3	4 a.m.	10 p.m.	1.81	2
837	283	3.3	174.1	36.5	168.0	S. 37° 36′ E.	215.6	1 a.m.	8 p.m.	.56	3
839	126	62.6	23.7	27.3	52.2	N. 32° 37′ E.	46.2	0	0	0	4
017	161	65.5	21.4	72.1	36.7	N. 38° 45′ W.	56.5	0	0	0	5
032	167	88.6	32.4	55.5	29.4	N. 24° 55′ W.	62.0	0	0	0	6
869	273	197.8	5.2	93.6	56.2	N. 10° 59′ W.	196.2	10 a.m.	6 p.m.	.51	7
141	246	223.1	0	27.2	57.5	N. 7° 44′ E.	225.2	0	0	0	8
56	154	33.3	76.0	3.2	96.9	S. 65° 30′ E.	103.0	0	0	0	9
097	179	95.5	57.6	33.0	37.9	N. 7° 22′ E.	38.2	0	0	0	10
077	330	116.2	148.6	13.9	157.5	S. 77° 17′ E.	147.2	0	0	0	11
36	360	326.7	3.6	69.0	21.5	N. 8° 22′ W.	326.6	0	0	0	12
98	164	5.0	101.5	0.8	116.3	S. 50° 08′ E.	150.6	0	0	0	13
73	138	38.9	67.6	31.1	37.3	S. 12° 11′ E.	29.4	0	0	0	14
92	205	166.6	17.4	19.7	49.3	N. 11° 13′ E.	152.1	1 p.m.	2 p.m.	.03	15
84	143	89.5	37.4	32.3	13.1	N. 20° 14′ W.	55.5	11 a.m.	12 p.m.	.19	16
45	179	64.9	89.6	9.9	57.5	S. 62° 34′ E.	53.6	0	0	0	17
62	146	44.8	73.9	12.8	57.8	S. 57° 07′ E.	53.6	0	0	0	18
63	242	31.3	111.9	2.7	158.6	S. 62° 40′ E.	175.5	0	0	0	19
58	195	21.3	116.2	14.2	100.6	S. 42° 19′ E.	128.4	1 p.m.	2 p.m.	.04	20
20	224	115.9	63.4	50.1	48.3	N. 1° 58′ W.	52.5	7 a.m.	8 a.m.	.03	21
40	124	45.6	48.3	13.7	53.7	S. 86° 08′ E.	40.0	0	0	0	22
2	283	153.4	84.6	27.0	84.9	N. 40° 05′ E.	89.9	9 p.m.	10 p.m.	.15	23
50	222	78.9	91.1	61.7	49.6	S. 44° 46′ W.	17.2	0	0	0	24
37	355	332.9	0	67.7	22.4	N. 7° 45′ W.	336.0	3 p.m.	5 p.m.	.46	25
4	179	0	124.1	0	127.5	S. 45° 46′ E.	178.0	3 a.m.	12 p.m.	.25	26
0	209	21.4	95.3	15.1	142.2	S. 59° 50′ E.	147.0	1 a.m.	a.m	.06	27
3	169	118.5	19.8	42.8	23.9	N. 10° 51′ W.	100.5	0	0	T	28
9	205	42.9	113.8	3.2	113.1	S. 57° 11′ E.	130.8	0	0	0	29
0	171	58.0	74.4	15.4	71.3	S. 73° 39′ E.	58.2	0	0	0	30
8	291	262.4	0	36.3	17.7	N. 4° 03′ W.	263.1	0	0	T	31
..	6834	2970.9	2280.3	915.4	2509.2	....	......	....	....	4.12	......
3.92	......	......	......	......	......	....	......	....	....	......	......
..	......	......	......	......	......	....	......	....	....	......	......

MONTHLY SUMMARY OF

JUNE,

DATE.	Thermometers. Temperatures. Mean of 24 h.	Extremes. Max.	Extremes. Min.	Hours of Extremes. Max.	Hours of Extremes. Min.	Psychrometer. Relative Humidity. 6 AM	12 M.	6 PM	Dew-point. 6 AM	12 M.	6 PM	Sunshine Reco[…] Clouds at Observ'n.	Number o[…] Minutes Act-ual.	Pos-sible.
1	60.1	74	43	3 p.m.	5 a.m.	54	24	33	34	32	35	17	614	856
2	53.9	60	49	6 p.m.	6 a.m.	65	72	59	39	44	43	16	459	857
3	44.8	50	37	1 a.m.	10 a.m.	93	80	86	43	39	38	30	152	858
4	49.2	58	41	1 p.m.	2 a.m.	74	45	66	37	35	41	21	458	859
5	50.2	57	39	6 p.m.	4 a.m.	73	57	58	36	39	42	20	715	859
6	57.5	71	39	5 p.m.	5 a.m.	81	42	31	41	43	38	0	813	860
7	63.7	78	46	2 p.m.	5 a.m.	57	17	38	39	27	41	17	651	861
8	.....	65	50	4 p.m.	12 p.m.	77	74	74	46	49	49	29	314	862
9	50.6	56	46	5 p.m.	12 m.	81	94	67	41	46	43	23	273	862
10	58.7	72	41	4 p.m.	5 a.m.	81	38	43	41	41	46	0	807	862
11	58.4	75	48	11 a.m.	4 a.m.	72	71	72	45	51	45	16	469	862
12	58.3	67	48	3 p.m.	4 a.m.	94	64	75	47	54	53	24	569	863
13	55.0	64	49	6 p.m.	3 a.m.	88	80	75	48	54	52	24	302	863
14	59.0	70	50	11 a.m.	5 a.m.	83	58	49	48	54	43	21	438	863
15	63.6	74	52	12 m.	1 a.m.	39	19	50	39	28	44	14	586	863
16	59.2	67	49	12 m.	6 a.m.	68	60	63	46	50	50	15	680	863
17	62.7	76	50	10 a.m.	4 a.m.	68	26	43	46	38	41	19	488	863
18	61.2	72	49	12 m.	4 a.m.	55	43	41	41	44	42	21	700	864
19	62.8	75	47	4 p.m.	5 a.m.	71	30	33	43	38	41	5	767	864
20	60.8	73	49	1 p.m.	4 a.m.	64	39	61	46	45	46	7	644	865
21	59.5	70	50	3 p.m.	5 a.m.	78	60	70	47	52	49	19	600	865
22	63.3	76	51	4 p.m.	5 a.m.	94	16	17	50	25	27	12	754	865
23	65.8	80	49	4 p.m.	5 a.m.	47	19	34	39	31	40	10	742	865
24	64.1	81	51	2 p.m.	5 a.m.	68	20	44	46	33	42	5	767	864
25	52.9	62	47	1 p.m.	5 a.m.	57	35	62	32	31	41	25	452	864
26	53.5	64	42	4 p.m.	5 a.m.	75	48	82	40	40	46	14	623	86[illegible]
27	60.4	76	44	4 p.m.	6 a.m.	82	33	30	43	41	38	4	795	86[illegible]
28	67.6	80	47	3 p.m.	5 a.m.	45	12	21	35	20	35	11	847	86[illegible]
29	63.6	74	53	3 p.m.	4 a.m.	60	36	60	44	43	52	7	738	86[illegible]
30	68.2	83	50	12 m.	5 a.m.	64	17	33	46	32	41	13	794	86[illegible]
Sums,	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Means,	58.9	70.0	47.0	.....	.....	71	44	52	42	40	43	.....	.....	.....
Perctg.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	51%	...	...

INSTRUMENTAL RECORD.

1904.

ROM.	ANEMOMETER AND ANEMOSCOPE. WIND.							RAIN GAUGE.			
ual sure 2 M.	Total Velocity.	Sum of Components.				Equivalent.		Hours of Fall.		Total Amount.	Date.
		N.	S.	W.	E.	Direction.	Miles.	Earliest.	Latest.		
.910	224	123.9	34.8	93.1	34.9	N. 33° 09′ W.	106.4	10 p.m.	10 p.m.	.02	1
.845	116	54.5	40.6	15.1	33.9	N. 53° 32′ E.	23.4	11 a.m.	3 p.m	.12	2
.747	267	271.8	0	22.2	14.8	N. 1° 34′ W.	271.9	4 a.m.	6 p.m.	.28	3
.965	134	49.7	41.8	29.6	59.4	N. 75° 09′ E.	30.8	3 p.m.	10 p.m.	.11	4
.202	175	47.0	87.8	6.5	92.5	S. 64° 37′ E.	95.2	0	0	0	5
.079	158	49.7	79.0	1.7	70.1	S. 66° 49′ E.	74.4	0	0	0	6
.984	229	62.4	132.5	36.4	51.3	S. 12° 00′ E.	71.7	0	0	T	7
.037	206	121.5	33.3	35.3	65.9	N. 19° 08′ E.	93.4	5 a.m.	12 p.m.	.10	8
.131	117	69.2	28.1	4.9	42.8	N. 42° 41′ E.	55.9	1 a.m.	2 p.m.	.33	9
.079	128	44.2	58.9	8.4	56.7	S. 73° 04′ E.	50.5	0	0	0	10
.148	156	78.7	23.6	55.3	29.5	N. 25° 05′ W.	60.8	12 m.	10 p.m.	1.38	11
.159	191	61.1	81.4	14.7	84.3	S. 73° 44′ E.	72.5	6 p.m.	6 p.m.	.10	12
.183	120	75.6	20.9	11.2	30.2	N. 19° 09′ E.	57.9	1 p.m.	4 p.m.	.07	13
.080	110	57.0	23.0	25.0	33.0	N. 13° 14′ E.	34.9	0	0	T	14
.138	147	59.7	54.6	25.4	38.8	N. 69° 10′ E.	14.3	3 p.m.	4 p.m.	.07	15
.167	131	69.6	29.3	35.4	27.9	N. 10° 33′ W.	41.0	1 p.m.	5 p.m.	.05	16
.172	181	112.2	17.6	59.4	37.6	N. 12° 59′ W.	97.1	0	0	T	17
.167	169	110.2	36.3	42.0	17.2	N. 18° 33′ W.	78.0	0	0	T	18
.120	166	246.5	0	13.1	33.8	N. 4° 48′ E.	247.3	0	0	0	19
.096	186	77.9	66.7	17.4	81.7	N. 80° 07′ E.	65.3	4 p.m.	5 p.m.	.24	20
.082	128	51.3	50.6	20.2	45.2	N. 88° 24′ E.	25.0	1 p.m.	12 p.m.	.05	21
.932	201	70.5	52.2	120.6	16.9	N. 80° 00′ W.	105.3	0	0	0	22
.984	145	59.3	60.9	19.5	49.0	S. 86° 49′ E.	29.6	0	0	0	23
996	283	220.8	33.6	67.6	26.3	N. 12° 27′ W.	191.6	0	0	0	24
274	197	97.2	77.9	6.3	54.0	N. 67° 58′ E.	51.5	4 p.m.	5 p.m.	.06	25
233	210	6.7	144.9	20.5	116.0	S. 34° 39′ E.	168.0	12 m.	8 p.m.	.49	26
133	86	24.0	49.7	19.0	16.1	S. 6° 26′ W.	25.8	0	0	0	27
.088	174	132.4	0	80.6	5.9	N. 29° 26′ W.	152.0	0	0	0	28
156	180	76.4	68.3	39.4	46.3	N. 40° 25′ E.	10.6	7 p.m.	7 p.m.	.02	29
134	156	71.9	56.5	24.8	33.2	N. 28° 37′ E.	17.5	0	0	0	30
....	....	....	....	....	....	....	....	....	....	....	....
....	5071	2652.9	1484.8	970.6	1345.2	....	....	....	....	3.49	....
081	....	....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....

MONTHLY SUMMARY OF

JULY,

DATE.	THERMOMETERS.					PSYCHROMETER.						SUNSHINE RECOR		
	TEMPERATURES.			Hours of Extremes.		Relative Humidity.			Dew-point.			Clouds at Observ'n.	Number of Minutes.	
	Mean of 24 h.	Extremes.												
		Max.	Min.	Max.	Min.	6 AM	12 M.	6 PM	6 AM	12 M.	6 PM		Act-ual.	Pos-sible
1	62.5	73	51	10 a.m.	4 a.m.	63	44	53	44	47	44	18	.....	862
2	58.4	74	45	2 p.m.	6 a.m.	76	45	47	43	73	43	10	.....	862
3	59.5	72	46	12 m.	5 a.m.	54	36	48	39	41	45	15	.....	862
4	60.7	72	47	4 p.m.	5 a.m.	82	61	35	46	53	42	4	.....	860
5	60.5	74	49	1 p.m.	4 a.m.	68	42	57	46	47	46	14	.....	860
6	54.5	62	48	1 p.m.	11 p.m.	77	62	75	46	48	51	20	.....	860
7	55.0	65	43	5 p.m.	4 a.m.	81	66	78	42	49	49	21	.....	860
8	63.8	76	47	3 p.m.	5 a.m.	88	46	42	49	51	47	8	.....	859
9	69.0	84	53	3 p.m.	2 a.m.	57	15	33	46	30	44	6	.....	859
10	66.7	82	54	1 p.m.	2 a.m.	62	27	58	48	42	54	20	.....	857
11	69.7	85	53	2 p.m.	3 a.m.	54	22	37	46	39	46	7	.....	857
12	65.9	78	52	2 p.m.	6 a.m.	71	45	44	51	53	47	12	.....	856
13	70.3	84	53	2 p.m.	3 a.m.	56	9	23	43	17	36	3	.....	856
14	66.2	76	50	4 p.m.	5 a.m.	72	36	31	45	43	41	1	.....	854
15	74.2	89	52	4 p.m.	4 a.m.	79	9	13	50	23	30	4	.....	852
16	73.9	85	60	3 p.m.	12 p.m.	43	22	40	44	41	47	18	.....	850
17	71.5	85	53	4 p.m.	5 a.m.	65	30	20	47	46	38	5	.....	849
18	72.4	81	58	4 p.m.	3 a.m.	22	23	27	31	36	42	6	.....	847
19	60.0	82	60	12 m.	6 a.m.	54	33	36	45	48	43	16	.....	846
20	65.2	77	53	3 p.m.	5 a.m.	70	40	52	50	48	48	13	.....	844
21	......	79	51	1 p.m.	4 a.m.	78	39	56	48	49	49	8	.....	843
22	61.2	72	48	5 p.m.	5 a.m.	78	43	79	47	46	52	16	.....	841
23	63.7	76	49	5 p.m.	5 a.m.	89	57	29	51	52	41	18	.....	839
24	62.1	76	53	5 p.m.	5 a.m.	58	80	95	47	54	58	20	.....	837
25	65.5	78	51	3 p.m.	5 a.m.	78	24	36	48	36	44	3	.....	837
26	65.0	78	52	2 p.m.	5 a.m.	78	34	43	49	47	44	10	.....	836
27	65.5	82	51	12 m.	5 a.m.	82	28	71	49	41	52	16	.....	835
28	64.6	79	52	1 p.m.	5 a.m.	67	37	69	52	50	47	14	.....	833
29	69.5	81	55	2 p.m.	3 a.m.	39	36	44	45	50	48	21	.....	831
30	67.0	78	57	2 p.m.	4 a.m.	70	40	57	50	48	52	21	.....	829
31	64.1	84	58	6 p.m.	12 p.m.	90	45	47	56	45	48	25	.....	827
Sums,	1948.1	2419	1604	....	....	2101	1176	1475	1443	1393	1418	393	.....	.....
Means,	64.9	78.0	51.7	....	....	68	38	48	47	45	46	13	.....	.....
Perctg.	......	.....	.....	....	....	.....	.....	.....	.....	.....	.....	44	.....	.....

INSTRUMENTAL RECORD.

1904.

…om.	Anemometer and Anemoscope.								Rain Gauge.			
	Wind.								Hours of Fall.		Total Amount.	Date.
…al …ure …M.	Total Velocity.	Sum of Components.				Equivalent.						
		N.	S.	W.	E.	Direction.	Miles.		Earliest.	Latest.		
112	171	80.5	52.5	44.9	36.4	N. 16° 53′ W.	29.2		0	0	T	1
044	148	90.6	22.7	20.9	44.9	N. 19° 28′ E.	72.2		3 p.m.	4 p.m.	.23	2
118	149	97.0	20.4	43.3	17.1	N. 18° 53′ W.	80.9		2 p.m.	6 p.m.	.23	3
082	136	74.0	36.5	33.0	33.2	N. 0° 19′ E.	37.5		0	0	T	4
006	270	227.1	10.6	72.3	24.8	N. 12° 23′ W.	221.6		5 p.m.	7 p.m.	.07	5
070	235	96.8	89.1	22.5	115.8	N. 85° 17′ E.	93.6		3 p m.	8 p.m.	.03	6
067	134	66.7	46.6	15.6	43.4	N. 54 °08′ E.	34.3		1 p.m.	7 p.m	.35	7
088	135	62.9	39.6	13.4	50.9	N. 58° 09′ E.	44.1		0	0	T	8
192	147	118.7	1.7	38.6	22.7	N. 7° 44′ W.	118.1		0	0	0	9
193	134	87.9	23.3	23.2	27.2	N. 3° 33′ E.	64.6		0	0	T	10
181	164	130.8	19.5	29.7	11.5	N. 9° 17′ W.	112.8		0	0	0	11
021	145	28.0	89.1	13.3	62.0	S. 38° 33′ E.	78.1		0	0	0	12
2858	184	135.6	15.5	44.0	27.4	N. 7° 53′ W.	121.1		0	0	0	13
2112	284	47.6	183.5	4.4	148.6	S. 46° 42′ E.	198.2		0	0	0	14
2935	230	50.1	101.2	76.2	51.9	S. 25° 26′ W.	56.5		0	0	0	15
2010	146	70.3	40.8	21.9	50.0	N. 43° 36′ E.	40.7		0	0	T	16
029	158	44.8	82.8	9.4	68.2	S. 57° 08′ E.	70.0		0	0	0	17
203	228	141.4	11.0	70.7	62.8	N. 3° 28′ W.	130.6		0	0	0	18
222	177	117.5	43.1	17.5	41.4	N. 17° 49′ E.	78.1		....	....	.02	19
251	139	30.3	83.3	8.5	57.0	S. 42° 28′ E.	71.8		....	....	.02	20
183	160	119.5	28.6	14.1	27.9	N. 8° 38′ E.	91.9		4 p.m.	4 p.m.	.02	21
264	160	55.6	77.7	21.1	53.7	S. 55° 52′ E.	39.3		6 p.m.	7 p.m.	.07	22
200	93	21.4	58.3	1.9	38.2	S. 44° 32′ E.	51.7		0	0	0	23
187	166	134.2	0.9	53.1	12.2	N. 17° 03′ W.	139.5		12 a.m.	10 p.m.	1.54	24
198	130	63.0	36.6	17.0	45.1	N. 46° 47′ E.	38.5		0	0	0	25
217	127	36.6	49.2	35.0	38.4	S. 74° 54′ E.	13.0		3 p.m.	6 p.m.	.27	26
182	137	69.8	30.7	54.2	19.6	N. 48° 29′ W.	52.2		....	5 p.m.	.07	27
081	142	91.0	35.8	30.0	20.1	N. 10° 10′ W.	56.0		4 p.m.	7 p.m.	.12	28
025	276	131.7	17.6	184.3	30.3	N. 52° 28′ W.	191.7		3 p.m.	6 p.m.	.05	29
103	118	72.9	25.0	24.9	29.8	N. 5° 50′ E.	48.1		0	0	T	30
206	112	70.3	17.8	33.6	15.6	N. 18° 56′ W.	55.4		4 p.m.	4 p.m.	.01	31
74 540	5135	2664.6	1391.0	1092.5	1328.1	....	......		....	....	3.10	......
2 117	......	......	......	......	......	....	......		....	....	......	......
......	......	......	......	......	......	....	......		....	....	......	......

MONTHLY SUMMARY OF

AUGUST,

DATE.	THERMOMETERS. Temperatures. Mean of 24 h.	Extremes. Max.	Extremes. Min.	Hours of Extremes. Max.	Hours of Extremes. Min.	PSYCHROMETER. Relative Humidity. 6 AM	Relative Humidity. 12 M.	Relative Humidity. 6 PM	Dew-point. 6 AM	Dew-point. 12 M.	Dew-point. 6 PM	Clouds at Observ'n.	SUNSHINE RECOR[D] Number of Minutes. Actual.	Number of Minutes. Possible.
1	64.3	73	54	3 p.m.	5 a.m.	89	52	53	54	53	49	16	.....	824
2	62.6	75	57	3 p.m.	4 a.m.	89	50	33	55	53	41	15	.....	821
3	66.0	80	53	12 m.	4 a.m.	79	32	51	50	45	50	19	.....	818
4	66.1	75	58	1 p.m.	1 a.m.	67	32	54	51	42	50	21	.....	816
5	65.2	79	54	12 m.	6 a.m.	89	45	58	54	53	54	8	.....	814
6	66.2	80	51	3 p.m.	5 a.m.	68	28	33	46	41	42	5	.....	812
7	60.1	68	49	2 p.m.	3 a.m.	68	52	87	46	48	54	22	.....	809
8	64.0	80	51	5 p.m.	4 a.m.	88	42	21	50	51	35	16	.....	807
9	66.8	78	52	1 p.m.	3 a.m.	52	34	44	42	46	48	2	.....	805
10	67.2	82	51	1 p.m.	5 a.m.	64	41	29	45	54	41	9	.....	803
11	69.0	83	54	2 p.m.	4 a.m.	61	30	52	46	46	53	12	.....	800
12	71.0	82	55	3 p.m.	6 a.m.	66	32	37	49	45	48	12	.....	798
13	71.2	85	61	4 p.m.	6 a.m.	76	34	44	56	50	52	12	.....	796
14	67.6	79	55	12 m.	5 a.m.	75	40	65	53	52	55	20	.....	794
15	68.8	84	55	1 p.m.	5 a.m.	70	33	49	50	48	52	11	.....	792
16	65.0	76	58	1 p.m.	4 a.m.	67	41	81	51	50	57	20	.....	790
17	62.8	71	53	12 m.	6 a.m.	84	61	76	52	54	56	20	.....	787
18	63.0	73	58	1 p.m.	3 a.m.	90	62	72	56	56	56	26	.....	784
19	66.8	81	54	11 a.m.	4 a.m.	55	23	39	42	36	42	13	.....	780
20	69.7	83	53	4 p.m.	5 a.m.	41	21	21	38	35	35	2	.....	777
21	54.3	65	45	1 a.m.	4 p.m.	67	78	70	43	48	41	21	.....	773
22	56.0	69	45	5 p.m.	5 a.m.	94	74	54	45	49	50	21	.....	772
23	68.0	84	45	3 p.m.	5 a.m.	77	26	32	46	40	47	4	.....	770
24	72.5	85	63	4 p.m.	12 n't	33	25	32	38	39	47	6	.....	769
25	58.9	64	56	11 a.m.	7 a.m.	63	66	84	44	48	52	26	.....	767
26	65.5	78	52	3 p.m.	6 a.m.	88	31	40	50	30	47	10	.....	764
27	69.1	82	57	4 p.m.	6 a.m.	62	41	57	48	50	51	13	.....	760
28	64.4	81	53	1 p.m.	6 a.m.	66	36	61	48	50	54	16	.....	758
29	59.7	77	53	11 a.m.	12 m't	57	95	89	51	53	54	27	.....	755
30	62.3	76	51	12 m.	2 a.m.	94	36	65	51	47	56	19	.....	752
31	66.8	78	51	3 p.m.	6 a.m.	72	32	44	44	45	48	15	.....	750
Sums,	2020.9	2406	1657	....	....	2229	1325	1627	1494	1457	1517	459	.....	.....
Means,	65.2	77.6	53.5	....	....	72	43	52	48	47	49	15	.....	.....
Perctg.	......	.....	.....	....	....	.....	.....	.....	.....	.....	.....	50%	.....	.....

INSTRUMENTAL RECORD.

1904.

BAROM.	ANEMOMETER AND ANEMOSCOPE. WIND.							RAIN GAUGE.			DATE.
Actual Pressure 12 M.	Total Velocity.	Sum of Components. N.	S.	W.	E.	Equivalent. Direction.	Miles.	Hours of Fall. Earliest.	Latest.	Total Amount.	
.234	......	......	......	......	......	....	......	4 p.m.	4 p.m.	.01	1
.161	157	3.7	96.3	16.6	96.3	S. 40° 43′ E.	122.2	0	0	0	2
.098	136	63.8	34.0	69.6	5.3	N. 65° 08′ W.	70.8	3 p.m.	3 p.m.	.01	3
.261	217	105.7	78.9	21.0	71.7	N. 62° 08′ E.	57.3	0	0	0	4
.247	126	48.9	44.2	16.9	55.6	N. 0° 05′ E.	39.0	0	0	0	5
.267	139	46.4	77.0	12.2	40.3	S. 42° 34′ E.	41.5	0	0	0	6
.227	260	192.4	31.2	26.3	64.8	N. 13° 26′ E.	165.7	6 p.m.	9 p.m	.26	7
.112	119	39.3	36.6	39.8	34.1	N. 64° 39′ W.	6.3	0	0	T	8
.224	242	146.1	63.4	23.5	60.7	N. 24° 13′ E.	90.6	0	0	0	9
.157	171	51.4	60.6	76.3	25.2	S. 79° 48′ W.	51.9	0	0	0	10
.139	165	92.5	46.5	42.1	34.0	N. 9° 59′ W.	46.7	7 p.m.	7 p.m.	.05	11
.229	242	144.8	2.2	119.9	31.6	N. 31° 46′ W.	167.7	0	0	0	12
.288	185	146.4	22.7	32.8	20.3	N. 5° 46′ W.	124.4	0	0	0	13
.285	128	67.2	18.8	46.1	25.0	N. 23° 33′ W.	52.8	6 p.m.	6 p.m.	.34	14
.159	159	137.8	0	46.9	13.5	N. 13° 38′ W.	141.8	0	0	0	15
.180	137	57.5	42.5	26.4	45.7	N. 52° 09′ E.	24.4	5 p.m.	11 p.m.	.14	16
.175	88	49.8	18.7	26.0	17.0	N. 16° 08′ W.	32.2	4 p.m.	5 p.m.	.03	17
.116	86	44.3	19.8	21.7	19.8	N. 4° 26′ W.	24.5	3 p.m.	3 p.m.	.03	18
.075	150	88.3	36.6	51.2	18.8	N. 32° 05′ W.	61.0	5 p.m.	5 p.m.	.02	19
.026	191	70.1	100.8	18.5	43.7	S. 39° 23′ E.	39.7	0	0	0	20
.160	203	181.7	6.8	10.5	35.6	N. 8° 10′ E.	176.7	12 m.	4 p.m.	.20	21
.307	116	21.8	72.5	14.8	41.8	S. 28° 02′ E.	57.4	0	0	0	22
.174	120	75.7	17.9	33.1	23.1	N. 9° 49′ W.	58.6	0	0	0	23
.183	204	69.7	51.3	114.6	30.7	N. 77° 38′ W.	85.9	9 p.m.	9 p.m.	.07	24
.396	208	117.3	51.5	18.5	80.2	N. 43° 10′ E.	90.2	8 p.m.	8 p.m.	.01	25
242	104	33.6	56.0	7.7	32.2	S. 47° 34′ E.	33.2	0	0	0	26
187	184	114.1	54.2	37.4	10.9	N. 23° 52′ W.	65.5	9 p.m.	10 p.m.	.07	27
177	156	121.4	2.4	47.1	19.7	N. 12° 58′ W.	122.1	7 p.m.	7 p.m.	.01	28
278	145	82.9	11.4	79.1	4.1	N. 46° 22′ W.	103.6	11 a.m.	6 p.m.	1.25	29
142	82	64.6	9.4	16.8	9.0	N. 8° 09′ W.	55.7	0	0	0	30
106	112	77.2	12.5	23.0	23.0	N. 0° 00′	64.7	0	0	0	31
7[illegible]012	4732	2556.4	1176.7	1136.4	1033.7	....	......	....	....	2.50	......
[illegible]194	......	......	......	......	......	....	......	....	....	......	......
...	......	......	......	......	......	....	......	....	....	......	......

MONTHLY SUMMARY OF

SEPTEMBER,

Date.	Thermometers.					Psychrometer.						Sunshine Recor		
	Temperatures.			Hours of Extremes.		Relative Humidity.			Dew-point.			Clouds at Observ'n.	Number of Minutes.	
	Mean of 24 h.	Extremes. Max.	Extremes. Min.	Max.	Min.	6 A M	12 M.	6 P M	6 A M	12 M.	6 P M		Actual.	Possible.
1	62.5	73	51	2 p.m.	12 n't.	84	44	27	51	47	31	18	88	745
2	57.1	71	45	12 m.	6 a.m.	93	33	64	44	38	45	15	290	742
3	56.6	66	43	3 p.m.	5 a.m.	87	43	53	41	41	44	4	460	739
4	59.3	74	43	4 p.m.	5 a.m.	87	34	38	41	40	41	1	517	737
5	62.8	78	45	3 p.m.	6 a.m.	76	19	19	41	31	28	3	578	734
6	62.5	78	45	4 p.m.	6 a.m.	75	17	26	40	27	36	1	586	732
7	65.0	83	47	3 p.m.	4 a.m.	46	17	27	33	30	37	10	490	729
8	66.5	82	48	2 p.m.	4 a.m.	44	19	27	34	34	37	2	598	725
9	66.3	82	47	4 p.m.	3 a.m.	34	20	24	28	33	36	15	445	722
10	63.9	75	50	2 p.m.	12 n't.	37	32	47	34	38	43	23	81	720
11	53.0	64	42	3 p.m.	5 a.m.	73	40	46	36	35	37	9	426	715
12	62.7	80	39	3 p.m.	3 a.m.	50	18	19	33	29	28	20	367	711
13	53.5	62	43	3 p.m.	6 a.m.	56	50	46	31	38	37	5	465	706
14	53.8	66	42	5 p.m.	7 a.m.	72	43	49	34	36	23	13	415	704
15	67.1	81	45	2 p.m.	2 a.m.	48	17	33	40	30	41	17	399	702
16	64.5	76	47	3 p.m.	5 a.m.	59	22	36	36	31	41	21	308	700
17	65.4	77	52	1 p.m.	11 p.m.	41	21	47	37	32	52	19	.....	697
18	66.6	79	49	2 p.m.	5 a.m.	38	13	31	32	26	38	15	.....	696
19	66.4	79	49	4 p.m.	5 a.m.	35	18	40	25	29	40	15	438	694
20	54.4	67	39	1 p.m.	6 a.m.	72	35	50	31	38	38	16	401	693
21	57.3	70	42	2 p.m.	6 a.m.	68	37	44	35	39	47	8	398	690
22	62.4	72	48	4 p.m.	2 a.m.	55	31	42	35	38	43	25	149	689
23	64.1	72	54	2 p.m.	5 a.m.	51	25	37	40	34	39	21	166	687
24	65.2	78	49	4 p.m.	6 a.m.	41	24	34	28	34	40	6	550	685
25	66.8	79	48	2 p.m.	2 a.m.	43	18	22	36	29	31	17	527	681
26	65.4	78	53	3 p.m.	3 a.m.	45	24	33	35	36	42	10	407	679
27	62.2	76	49	2 p.m.	6 a.m.	41	33	56	28	42	49	18	292	675
28	58.5	67	53	3 p.m.	11 p.m.	61	49	53	40	41	44	23	250	671
29	52.6	56	48	1 p.m.	11 p.m.	76	83	100	43	50	56	30	0	668
30	53.0	59	46	2 p.m.	3 a.m.	82	94	78	45	49	48	30	87	666
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Sums,	1837.4	2200	1401	....	....	1770	963	1248	1087	1075	1192	430	.....	.....
Means,	61.2	73.3	46.7	....	....	59	32	42	36	36	40	14	.....	.....
Perctg.	......	......	......	......	......	......	......	......	......	......	....	47%	...	.....

INSTRUMENTAL RECORD.

1904.

From.	Anemometer and Anemoscope.								Rain Gauge.			Date.
	Wind.								Hours of Fall.		Total Amount.	
tual ssure 12 M.	Total Velocity.	Sum of Components.				Equivalent.						
		N.	S.	W.	E.	Direction.	Miles.		Earliest.	Latest.		
.091	229	167.6	20.4	41.4	61.3	N. 7° 42′ E.	148.5		4 p.m.	4 p.m.	.03	1
.184	129	92.0	10.1	17.6	43.7	N. 17° 41′ E.	85.9		4 p.m.	5 p.m.	.33	2
.325	135	29.4	65.5	10.2	74.5	S. 60° 41′ E.	73.7		2 a.m.	5 a.m.	.03	3
.216	115	53.6	48.8	1.8	36.0	N. 82° 01′ E.	34.5		0	0	0	4
.215	133	119.9	3.0	4.9	28.4	N. 11° 22′ E.	119.2		0	0	0	5
.306	131	81.3	32.4	5.6	34.0	N. 30° 09′ E.	56.5		0	0	0	6
.308	142	91.4	28.8	19.7	27.6	N. 7° 12′ E.	63.0		0	0	0	7
.294	134	94.5	15.0	10.1	31.8	N. 15° 16′ E.	82.4		0	0	0	8
.155	134	78.4	37.7	17.4	24.9	N. 10° 26′ E.	41.4		0	0	0	9
.066	256	190.8	32.7	71.2	17.7	N. 18° 42′ W.	166.9		0	0	T	10
.174	212	18.9	129.7	3.3	138.8	S. 50° 44′ E.	175.0		0	0	0	11
.049	198	136.0	30.4	45.5	26.2	N. 10° 21′ W.	107.4		0	0	0	12
.194	210	95.7	73.8	17.3	84.6	N. 71° 58′ E.	70.7		0	0	0	13
.303	188	37.5	105.7	1.1	108.2	S. 57° 31′ E.	127.0		0	0	0	14
.192	162	122.2	10.5	44.4	29.7	N. 7° 31′ W.	112.5		0	0	0	15
.151	129	75.7	22.3	38.2	22.7	N. 16° 11′ W.	55.6		0	0	0	16
048	232	......	......	......	......	....	......		0	0	T	17
110	131	......	......	......	......	....	......		0	0	0	18
210	162	111.2	27.3	42.4	25.9	N. 11° 08′ W.	85.5		0	0	0	19
269	147	27.7	69.0	3.3	94.9	S. 65° 45′ E.	100.5		0	0	0	20
204	129	44.0	57.2	7.1	57.4	S. 75° 18′ E.	52.0		0	0	T	21
093	199	61.6	97.0	32.9	61.1	S. 38° 32′ E.	45.2		0	0	0	22
075	124	40.2	31.9	74.0	15.6	N. 81° 55′ W.	59.0		0	0	0	23
159	138	60.5	44.6	31.9	41.0	N. 29° 47′ E.	18.3		0	0	0	24
134	147	27.3	82.6	18.9	63.8	S. 39° 04′ E.	71.2		0	0	0	25
020	209	79.8	82.6	26.0	71.9	S. 86° 31′ E.	46.0		0	0	0	26
2[illegible]42	200	50.3	105.1	11.7	93.7	S. 56° 15′ E.	98.6		0	0	T	27
2[illegible]071	263	241.2	0	77.9	9.8	N. 15° 46′ W.	250.6		0	0	0	28
299	146	92.6	6.5	78.4	7.7	N. 39° 23′ W.	111.4		9 a.m.	12 n't.	1.25	29
278	263	239.8	14.1	20.9	25.8	N. 1° 30′ E.	225.8		1 a.m.	5 a.m.	.43	30
......	......	......	......	......	......	....	......		......	......	......	......
72[illegible]035	5127	2561.1	1284.7	775.1	1358.7	....	......		......	......	2.07	......
2[illegible]168	......	......	......	......	......	....	......		......	......	......	......
......	......	......	......	......	......	....	......		......	......	......	......

MONTHLY SUMMARY OF

October,

Date.	Thermometers. Temperatures. Mean of 24 h.	Extremes. Max.	Extremes. Min.	Hours of Extremes. Max.	Hours of Extremes. Min.	Psychrometer. Relative Humidity. 6 AM	12 M.	6 PM	Dew-point. 6 AM	12 M.	6 PM	Sunshine Reco[rd] Clouds at Observ'n.	Number o[f] Minutes. Actual.	Possible.
1	57.3	69	47	4 p.m.	5 a.m.	87	52	63	44	48	42	10	441	664
2	58.6	70	47	2 p.m.	5 a.m.	59	36	49	35	41	43	1	534	662
3	60.0	73	44	3 p.m.	4 a.m.	65	25	40	39	34	40	13	496	660
4	60.0	73	49	1 p.m.	4 a.m.	48	18	34	31	26	35	0	578	656
5	46.4	54	40	1 a.m.	12 n't	62	75	74	34	40	38	26	37	654
6	44.7	50	39	9 p.m.	1 a.m.	100	100	100	40	42	48	30	0	653
7	62.1	74	48	2 p.m.	1 a.m.	52	19	41	42	26	38	5	582	651
8	56.7	68	46	11 a.m.	3 a.m.	51	40	100	30	40	56	24	217	647
9	57.8	66	48	1 p.m.	12 n't	70	26	26	41	29	25	7	440	644
10	52.0	61	40	3 p.m.	12 n't	65	26	55	30	25	35	2	540	642
11	50.4	66	31	2 p.m.	5 a.m.	81	38	51	26	32	40	15	479	639
12	56.5	70	39	3 p.m.	6 a.m.	63	19	31	28	26	30	10	482	635
13	48.5	65	34	3 p.m.	6 a.m.	74	36	56	27	29	38	6	428	633
14	49.0	61	37	4 p.m.	3 a.m.	60	54	51	30	39	39	11	338	631
15	56.5	73	38	4 p.m.	3 a.m.	73	20	31	36	28	32	4	417	629
16	58.5	69	40	3 p.m.	12 n't	63	52	55	43	47	41	1	560	626
17	47.7	57	35	2 p.m.	6 a.m.	70	38	59	29	29	36	15	330	623
18	32.2	40	24	1 a.m.	11 p.m.	90	58	58	28	22	22	23	49	620
19	36.5	46	25	5 p.m.	1 a.m.	78	32	61	21	18	25	6	369	617
20	......	59	....	4 p.m.	....	77	20	36	18	16	23	3	457	614
21	50.8	64	36	2 p.m.	2 a.m.	75	56	61	29	37	39	7	474	611
22	47.4	60	33	3 p.m.	7 a.m.	82	35	51	28	31	34	5	509	608
23	53.0	71	34	2 p.m.	2 a.m.	66	12	20	25	15	18	4	547	606
24	36.2	47	31	4 a.m.	12 n't	69	74	60	28	27	24	30	0	604
25	33.5	52	22	4 p.m.	7 a.m.	75	28	56	17	16	25	2	439	601
26	41.7	60	29	3 p.m.	1 a.m.	28	32	56	39	28	31	5	440	597
27	44.0	63	27	2 p.m.	6 a.m.	48	18	41	11	18	26	1	497	596
28	46.3	63	33	2 p.m.	12 n't	63	20	37	28	20	28	1	500	595
29	42.2	59	30	2 p.m.	7 a.m.	59	22	36	29	20	23	0	430	592
30	40.1	56	27	3 p.m.	4 a.m	59	25	61	17	20	32	4	480	589
31	42.5	60	30	2 p.m.	4 a.m.	61	24	50	20	22	29	1	488	587
Sums,	1469.1	1919	1083	....	....	2073	1130	1600	937	891	1035	272	.....	.....
Means,	49.0	61.9	36.1	....	....	67	36	52	30	29	33	9	.....	.....
Perctg.	.....	.....	.....	....	....	.....	.....	.....	.....	.....	.....	30%	.....	.....

INSTRUMENTAL RECORD.

1904.

ROM.	ANEMOMETER AND ANEMOSCOPE.							RAIN GAUGE.			DATE.
	WIND.							Hours of Fall.		Total Amount.	
ual sure 2 M.	Total Velocity.	Sum of Components.				Equivalent.		Earliest.	Latest.		
		N.	S.	W.	E.	Direction.	Miles.				
.162	78	21.1	36.3	14.5	25.8	S. 36° 38′ E.	18.9	0	0	0	1
.115	158	71.6	56.8	20.9	58.4	N. 68° 28′ E.	40.2	0	0	0	2
.073	148	80.1	41.3	18.8	39.7	N. 28° 19′ E.	44.0	0	0	0	3
.120	165	110.9	35.9	24.4	32.2	N. 5° 56′ E.	75.4	0	0	0	4
.327	261	104.3	115.7	14.0	105.0	S. 82° 52′ E.	91.7	9 p.m.	9 p.m.	.01	5
.094	132	36.6	64.7	0	80.4	S. 70° 44′ E.	85.2	2 a.m.	7 p.m.	.11	6
.911	190	47.6	63.3	94.7	40.6	S. 73° 49′ W.	56.3	0	0	0	7
.970	172	104.3	46.5	26.6	32.7	N. 6° 02′ E.	58.0	4 p.m.	7 p.m.	.15	8
.903	233	132.4	14.1	141.4	33.0	N. 42° 30′ W.	160.5	0	0	0	9
.202	213	78.7	75.0	47.1	72.1	N. 81° 35′ E.	25.2	0	0	0	10
.110	179	91.2	65.7	20.5	38.8	N. 35° 40′ E.	31.3	0	0	0	11
.911	259	113.1	110.0	46.8	49.6	N. 53° 08′ E.	3.5	0	0	0	12
.126	124	59.4	34.8	8.9	52.7	N. 60° 41′ E.	50.2	0	0	0	13
.163	115	42.8	45.8	11.2	50.5	S. 85° 38′ E.	39.4	0	0	0	14
.962	113	52.6	41.8	10.3	35.0	N. 66° 23′ E	26.9	0	0	0	15
.883	179	58.5	54.9	35.0	77.7	N. 85° 11′ E.	42.8	0	0	0	16
.973	187	128.5	25.2	33.7	48.2	N. 7° 59′ E.	104.4	0	0	0	17
.137	432	372.2	0	160.6	8.8	N. 22° 11′ W.	402.0	0	0	T	18
.203	215	199.4	0	34.3	25.9	N. 2° 25′ W.	199.6	0	0	0	19
.195	130	77.7	38.7	8.7	31.0	N. 29° 46′ E.	44.9	0	0	0	20
.152	180	89.0	63.1	14.8	62.2	N. 61° 21′ E.	54.0	0	0	0	21
318	156	73.3	55.0	15.9	57.4	N. 66° 12′ E.	45.3	0	0	0	22
065	155	107.9	25.4	32.6	28.7	N. 2° 42′ W.	82.6	0	0	0	23
261	274	235.0	4.4	62.2	27.9	N. 8° 28′ W.	233.1	0	0	T	24
261	95	33.2	39.6	7.5	41.0	S. 79° 11′ E.	34.1	0	0	0	25
326	129	114.2	5.7	18.8	13.7	N. 2° 42′ W.	108.6	0	0	0	26
211	160	147.6	1.2	16.6	25.3	N. 3° 24′ E.	146.7	0	0	0	27
93	161	132.5	9.6	21.1	26.5	N. 2° 31′ E.	123.0	0	0	0	28
67	193	89.0	71.2	14.2	72.5	N. 73° 01′ E.	60.9	0	0	0	29
46	175	91.6	55.2	5.0	60.5	N. 56° 53′ E.	66.2	0	0	0	30
12	154	142.3	1.0	13.4	20.6	N. 2° 55′ E.	141.5	0	0	0	31
47 52	5515	3238.6	1298.9	994.5	1374.4	....	.....	....	....	.27	.....
24 18	.....	.....	.....	.....	.....	....	.....	....	....	....	.....
.....	.....	.....	.....	.....	.....	....	.....	....	....	....	.....

MONTHLY SUMMARY OF

NOVEMBER,

DATE.	THERMOMETERS.					PSYCHROMETER.						SUNSHINE RECO[RD]			
	TEMPERATURES.			Hours of Extremes.		Relative Humidity.			Dew-point.			Clouds at observ'n.	Number o[f] Minutes.		
	Mean of 24 h.	Extremes.													
		Max.	Min.	Max.	Min.	6 AM	12 M.	6 PM	6 AM	12 M.	6 PM		Act-ual.	Pos-sible	r
1	45.5	61	31	2 p.m.	7 a.m.	53	46	38	18	37	26	1	479	586	2
2	42.4	59	27	1 p.m.	5 a.m.	69	22	48	20	20	26	3	473	582	[illegible]
3	42.2	54	26	3 p.m.	4 a.m.	36	34	56	5	25	31	15	436	579	5
4	40.9	55	30	2 p.m.	12 n't.	39	45	61	13	30	32	16	295	578	[illegible]
5	40.8	59	26	3 p.m.	6 a.m.	68	19	44	19	5	25	1	518	576	[illegible]
6	44.4	61	28	1 p.m.	3 a.m.	61	18	45	25	16	22	2	532	574	3
7	42.9	59	30	3 p.m.	2 a.m.	34	23	74	15	20	37	3	479	572	4
8	44.5	61	28	2 p.m.	2 a.m.	27	26	48	7	25	31	6	485	570	5
9	30.8	39	20	9 a.m.	12 n't.	48	89	72	17	26	24	17	5	568	1
10	19.2	24	7	4 p.m.	12 n't.	87	73	60	18	12	10	21	267	566	7
11	25.8	47	4	3 p.m.	4 a.m.	83	15	48	4	4	17	6	502	565	9
12	44.2	61	28	2 p.m.	12 n't.	59	28	35	23	27	19	3	510	563	0
13	40.9	61	25	1 p.m.	5 a.m.	74	12	38	23	11	22	1	.....	561	...
14	44.1	62	26	2 p.m.	2 a.m.	54	18	37	19	16	20	7	.....	560	...
15	44.9	60	25	2 p.m.	8 a.m.	59	30	39	17	28	23	7	486	558	4
16	47.7	56	32	2 p.m.	11 p.m.	32	32	35	24	24	19	12	313	556	6
17	45.6	62	27	1 p.m.	5 a.m.	39	12	31	13	11	16	6	.....	554	...
18	49.8	67	28	3 p.m.	4 a.m.	53	28	32	18	25	28	6	282	552	1
19	43.2	52	25	5 a.m.	12 n't.	51	28	50	25	20	24	3	464	551	4
20	38.0	55	18	2 p.m.	6 a.m.	74	26	64	15	20	29	8	417	549	6
21	49.7	65	32	2 p.m.	12 n't.	36	26	44	23	27	25	4	416	548	6
22	44.3	63	32	9 p.m.	5 a.m.	41	26	41	15	20	26	22	0	547	0
23	45.4	61	29	1 p.m.	7 a.m.	73	26	50	26	25	29	3	434	545	0
24	45.4	65	26	1 p.m.	12 n't.	49	24	40	22	26	21	0	475	543	37
25	32.5	49	18	4 p.m.	6 a.m.	63	29	43	12	14	16	0	438	541	81
26	39.7	56	24	2 p.m.	5 a.m.	71	26	41	22	22	22	1	441	539	82
27	50.4	65	33	4 p.m.	1 a.m.	55	18	30	24	21	21	6	434	539	81
28	......	62	35	....	12 n't.	35	12	26	19	11	16	6	493	537	92
29	30.6	41	19	12 m.	6 a.m.	39	45	64	3	24	23	13	326	537	61
30	40.3	58	19	3 p.m.	3 a.m.	19	41	39	–7	33	23	25	130	536	24
....	....	.....	.....	....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...
Sums,	1196.1	1700	758	....	....	1581	897	1373	497	625	703	224	.....	.....	383
Means,	41.2	56.7	25.3	....	....	53	30	46	17	21	23	7	.....	.....	...
Perctg.	.....	.....	.....	....	....	.....	.....	.....	.....	.....	.....	23%	.....	.....	70%

INSTRUMENTAL RECORD.

1904.

Barom.	Anemometer and Anemoscope.							Rain Gauge.			
	Wind.							Hours of Fall.			
Actual Pressure at 12 M.	Total Velocity.	Sum of Components.				Equivalent.		Earliest.	Latest.	Total Amount.	Date.
		N.	S.	W.	E.	Direction.	Miles.				
24.170	158	121.4	21.0	25.0	21.7	N. 1° 53′ W.	100.5	0	0	0	1
.074	166	109.6	39.7	14.1	37.2	N. 18° 17′ E.	73.6	0	0	0	2
.135	167	95.4	41.2	16.2	58.5	N. 37° 58′ E.	68.7	0	0	0	3
.130	139	110.9	11.8	8.5	33.0	N. 13° 53′ E.	102.1	0	0	0	4
.131	145	106.0	24.1	14.6	27.6	N. 9° 01′ E.	82.9	0	0	0	5
.157	177	138.2	28.9	10.8	22.8	N. 6° 16′ E.	110.0	0	0	0	6
.276	162	149.9	0	28.4	20.6	N. 2° 59′ W.	149.9	0	0	0	7
.244	164	151.7	0	28.5	21.0	N. 2° 50′ W.	151.9	0	0	0	8
.243	299	263.0	0	97.3	2.9	N. 19° 41′ W.	279.3	0	0	T	9
.385	310	293.3	0	69.0	6.7	N. 12° 0′ W.	299.8	0	0	T	10
.235	225	221.6	0	19.3	11.9	N. 1° 55′ W.	221.8	0	0	0	11
.117	267	259.0	0	40.1	12.9	N. 6° 0′ W.	260.3	0	0	0	12
.111	174	118.4	30.4	21.6	32.1	N. 6° 48′ E.	88.6	0	0	0	13
.058	226	213.7	0	29.5	18.8	N. 2° 52′ W.	214.0	0	0	0	14
.043	171	112.3	35.6	22.5	40.5	N. 13° 13′ E.	78.7	0	0	0	15
.157	191	82.0	64.6	51.1	55.1	N. 12° 57′ E.	17.8	0	0	0	16
.237	164	89.9	55.4	14.8	45.6	N. 41° 45′ E.	46.2	0	0	0	17
3.995	165	88.4	57.5	31.1	30.3	N. 1° 29′ W.	30.9	0	0	0	18
4.077	160	135.0	3.8	23.2	30.3	N. 3° 06′ E.	131.4	0	0	0	19
.080	127	76.4	33.7	19.9	26.8	N. 9° 11′ E.	43.2	0	0	0	20
.137	204	148.1	19.0	62.1	29.7	N. 14° 05′ W.	133.1	0	0	0	21
.125	126	100.8	7.2	26.1	15.5	N. 6° 28′ W.	94.1	0	0	0	22
.166	196	85.9	69.5	35.7	69.7	N. 64° 15′ E.	37.7	0	0	0	23
.102	167	144.8	0	28.6	29.2	N. 2° 22′ E.	145.1	0	0	0	24
.218	111	82.9	18.3	8.1	20.0	N. 10° 26′ E.	65.7	0	0	0	25
.341	153	113.0	24.7	24.9	26.3	N. 9° 07′ E.	88.8	0	0	0	26
.092	131	99.7	16.3	25.6	17.9	N. 5° 17′ W.	83.7	0	0	0	27
3.853	323	218.8	9.7	181.2	20.4	N. 37° 34′ W.	263.8	0	0	0	28
4.058	137	86.3	30.3	18.1	37.3	N. 18° 56′ E.	59.2	0	0	0	29
3.988	136	110.9	16.3	37.3	2.4	N. 20° 15′ W.	100.8	0	0	0	30
......	......	......	......	......	......	......	......	......	......	......	......
4.135	5441	4127.3	659.0	1033.2	824.7	......	......	......	......	T	......
4.138	......	......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......	......	......

MONTHLY SUMMARY OF

DECEMBER,

Date.	Thermometers.					Psychrometer.						Sunshine Recor		
	Temperatures.			Hours of Extremes.		Relative Humidity.			Dew-point.			Clouds at Observ'n.	Number of Minutes.	
	Mean of 24 h.	Extremes. Max.	Extremes. Min.	Max.	Min.	6 AM	12 M.	6 PM	6 AM	12 M.	6 PM		Actual.	Possible.
1	48.7	62	33	2 p.m.	12 n't.	41	21	33	22	22	23	5	508	535
2	29.0	36	23	1 p.m.	12 n't	55	68	59	21	27	17	16	266	533
3	23.0	26	20	3 p.m.	9 a.m	88	78	64	19	21	13	30	0	533
4	24.9	29	20	2 p.m.	12 n't	88	69	75	19	20	17	24	145	532
5	24.8	39	13	1 p.m.	6 a.m.	76	44	60	8	18	18	6	452	532
6	30.0	46	16	1 p.m.	2 a.m.	54	31	59	11	16	17	0	498	530
7	33.0	57	21	11 a.m.	2 a.m.	77	5	35	20	–9	12	2	483	530
8	38.4	56	22	12 m.	1 a.m.	35	17	34	12	19	17	9	397	528
9	33.0	50	21	2 p.m.	12 n't	52	39	48	10	23	17	10	443	528
10	37.6	56	19	2 p.m.	2 a.m.	43	29	36	6	23	17	6	470	528
11	30.3	40	17	2 p.m.	12 n't	.....	49	59	.....	13	17	.....	495	528
12	30.2	44	16	12 m.	5 a.m.	43	33	43	6	13	16	23	283	526
13	25.8	38	18	3 p.m.	11 p.m.	64	43	57	13	16	15	10	294	526
14	26.2	38	17	2 p.m.	4 p.m.	86	40	61	16	18	20	13	341	526
15	32.4	50	19	1 p.m.	5 a.m.	73	31	100	12	20	32	18	272	526
16	27.8	35	17	2 p.m.	12 n't	79	49	57	22	19	15	4	478	525
17	37.0	55	12	2 p.m.	4 a.m.	73	26	26	14	20	20	12	344	525
18	37.0	46	18	3 a.m.	12 n't	56	38	79	25	22	23	11	309	525
19	40.2	56	12	2 p.m.	3 a.m.	58	18	22	7	16	16	1	477	525
20	43.6	53	26	12 m.	11 p.m.	38	22	36	22	16	17	11	.....	524
21	40.0	58	25	2 p.m.	1 a.m.	44	22	38	18	20	22	2	.....	524
22	41.8	56	30	2 p.m.	8 a.m.	17	28	36	0	20	23	10	374	525
23	29.1	43	16	3 a.m.	12 n't	63	80	78	22	25	21	15	261	525
24	30.7	46	16	3 p.m.	1 a.m.	77	40	40	18	18	18	3	401	525
25	35.5	47	12	12 m.	12 n't	37	44	40	14	21	18	3	459	525
26	.....	16	1	12 m.	12 n't	66	53	42	5	2	6	19	245	526
27	6.5	21	–5	3 p.m.	4 a.m.	45	43	79	13	–3	2	2	456	526
28	20.5	40	2	3 p.m.	2 a.m.	62	54	78	0	23	21	6	393	527
29	32.2	56	17	5 p.m.	7 a.m.	72	24	44	11	16	18	0	489	527
30	40.3	63	22	4 p.m.	6 a.m.	65	10	23	15	4	14	1	504	528
31	44.8	66	30	3 p.m.	6 a.m.	41	12	19	15	11	13	0	500	528
Sums,	974.3	1424	546	....	....	1769	1160	1560	416	510	535	272	.....	.....
Means,	32.5	45.9	17.6	....	....	59	37	50	14	16	17	9	.....	.....
Perctg.	.....	.....	.....	....	....	.....	.....	.....	.....	.....	.....	30%	...	.....

INSTRUMENTAL RECORD.

1904.

BAROM.	ANEMOMETER AND ANEMOSCOPE.							RAIN GAUGE.			
	WIND.										
Actual Pressure at 12 M.	Total Velocity.	Sum of Components. N.	S.	W.	E.	Equivalent. Direction.	Miles.	Hours of Fall. Earliest.	Latest.	Total Amount.	Date.
23.853	148	104.4	13.1	55.4	19.8	N. 21° 18′ W.	98.0	0	0	0	1
24.009	129	28.8	62.6	1.1	75 8	S. 65° 39′ E.	81.9	0	0	0	2
.065	78	0	56.5	0	52.0	S. 42° 38′ E.	76.7	0	0	T	3
.116	186	169.5	2.5	11.1	19.2	N. 2° 47′ E.	167.1	....	....	.15	4
.227	130	85.3	31.0	19.2	25.9	N. 7° 02′ E.	54.7	0	0	0	5
.164	184	141.9	21.6	38.8	25.9	N. 6° 07′ W.	121.0	0	0	0	6
.137	178	127.4	30.3	30.7	27.5	N. 1° 53′ W.	97.2	0	0	0	7
23.946	144	123.4	6.5	24.6	19.7	N. 2° 24′ W.	117.0	0	0	0	8
24.036	104	69.9	19.2	10.7	26.1	N. 16° 54′ E.	52.9	0	0	0	9
23.891	354	165.2	35.5	242.0	14.3	N. 60° 20′ W.	262.0	0	0	0	10
24.075	262	148.8	36.0	114.1	41.4	N. 32° 48′ W.	134.2	0	0	0	11
23.880	181	126.4	30.5	27.9	37.9	N. 5° 57′ E.	96.4	0	0	0	12
.972	116	105.4	2.1	9.7	19.5	N. 5° 25′ E.	103.8	0	0	T	13
.979	140	119.7	4.1	25.1	25.0	N. 0° 03′ W.	115.6	0	0	0	14
.738	413	207.8	35.7	303.3	7.0	N. 59° 51′ W.	342.7	0	0	T	15
24.153	351	234.4	3.6	199.0	8.5	N. 21° 25′ W.	247.9	0	0	0	16
.050	379	217.4	5.6	283.8	0	N. 53° 16′ W.	354.5	0	0	0	17
.162	229	82.5	48.7	90.4	71.7	N. 28° 57′ W.	38.6	0	0	0	18
.072	374	170.5	20.7	264.5	11.8	N. 59° 20′ W	293.7	0	0	0	19
.103	......	......	......	......	......	....	......	0	0	0	20
23.994	......	......	......	......	......	....	......	0	0	0	21
.749	131	58.5	33.8	54.7	14.7	N. 58° 18′ W.	47.0	0	0	0	22
.921	251	28.0	113.6	37.6	160.6	S. 55° 10′ E.	149.9	0	0	0	23
.817	160	69.6	48.5	51.9	31.5	N. 44° 02′ W.	29.3	0	0	0	24
.598	375	151.9	67.0	231.7	10.8	N. 68° 59′ W.	236.7	0	0	0	25
.927	499	452.8	0	169.3	3.7	N. 20° 05′ W	482.2	....	....	.30	26
24.063	100	63.2	20.7	20.5	22.1	N. 2° 09′ E.	42.6	0	0	0	27
.032	145	126.3	2.7	25.7	16.0	N. 4° 29′ W.	124.1	0	0	0	28
23.996	171	163.4	0	19.3	7.8	N. 4° 02′ W.	163.7	0	0	0	29
.946	153	128.3	12.3	21.0	9.8	N. 5° 31′ W.	116.5	0	0	0	30
.867	158	......	......	......	......	....	......	0	0	0	31
743.538	6223	3670.7	764.4	2383.1	806.0	....	......	....	....	.45	......
23.985	......	......	......	......	......	....	......	....	....	......	......

ANNUAL SUMMARY, BY MONTHS.

Month.	Barometer. Mean at 12 M.	Barometer. Extremes. Max.	Barometer. Extremes. Min.	Barometer. Dates of Extremes. Max.	Barometer. Dates of Extremes. Min.	Thermometer. Mean.	Thermometer. Extremes. Max.	Thermometer. Extremes. Min.	Thermometer. Dates of Extremes. Max.	Thermometer. Dates of Extremes. Min.	Thermometer. Mean Max.	Thermometer. Mean Min.	Anemometer. Wind. Total Velocity	Anemometer. Wind. Max. Daily Velocity	Anemometer. Date.
January	23.929	24.16	23.55	13	9	26.8	62	-1	13	28	40.4	13.8	6649	176	9
February	.922	.26	.55	10	6	36.1	71	-1	27	10	50.3	21.3	5785	537	13
March	.871	.30	.44[2]	3	9	39.1	69	6	2	26	53.1	25.1	7852	724[1]	2
April	.936	.32	.52	1	21	46.0	73	15	10[3]	16	57.9	32.6	8196	690	24
May	.992	.20	.75	13	24	52.7	78	30	24	9	62.4	41.1	6831	131	2
June	24.081	.27	.75	25	3	58.9	83	37	30	3	70.0	47.0	5071	283	24
July	.117	.26	.86	22	13	64.9	89[1]	43	15	7	78.0	51.7	5135	284	14
August	.194	.40[1]	24.03	25	20	65.2	85	45	13[3]	21[3]	77.6	53.5	4732[4]	260[2]	7
September	.168	.32	23.84	3	27	61.2	83	39	7	12[3]	73.3	46.7	5127	263	28[3]
October	.118	.33	.88	5	16	49.0	74	22	7	25	61.9	36.1	5515	432	18
November	.138	.38	.85	10	28	41.2	67	4	18	11	56.7	25.3	5441	323	28
December	23.985	.23	.60	5	25	32.5	66	-5[2]	31	27	45.9	17.6	6223[5]	199	26
	288.451	291.43	284.62	......	......	573.6	......	......	......	......	727.5	411.8	72,560	......	......
	24.038	24.18	23.72	......	......	47.8	......	......	......	......	60.6	34.3	......	......	......

Month.	Psychrometer. Relative Humidity. 6 A.M.	Relative Humidity. 12 M.	Relative Humidity. 6 P.M.	Minimum Humidity.[7] Per ct.	Minimum Humidity. Date.	Dew-point. 6 A.M.	Dew-point. 12 M.	Dew-point. 6 P.M.	Percentages of Cloud and Sun. Cloud (Area)	Sunshine (Time)	Rain Gauge. Total Rain.	Rain Gauge. Max. in Day.	Number of Days. Max. below 32	Min. below 32	Max. above 80	Clear.	Part Cloudy	Cloudy	Rain.[6]
Jan.	62	31	47	1	9	10	7	10	29	75	0.11	0.08	7	31	0	23	1	1	2
Feb.	53	31	37	8	29[8]	13	15	14	31	80	0.19	0.10	1	25	0	19	8	2	2
Mar.	56	35	37	6	9	16	17	16	45	75	0.60	0.20	0	21	0	13	11	7	9
April	62	33	37	1	19	24	19	24	47	66	0.23	0.15	0	10	0	10	15	5	4
May	70	48	48	11	10	36	35	35	54	64	4.12	1.81	0	1	0	6	16	9	12
June	71	44	52	12	28	42	40	43	51	70	3.49	1.38	0	0	4	7	17	6	16
July	68	38	48	9	13	47	45	46	44	59	3.10	1.54[1]	0	0	12	13	17	1	15
Aug	72	43	52	21	20[3]	48	47	49	50	....	2.50	1.25	0	0	11	8	20	3	15
Sept	59	32	42	13	18	36	36	40	47	51	2.07	1.25	0	0	4	11	14	5	5
Oct	67	36	52	12	23	30	29	33	30	65	0.27	0.15	0	10	0	22	5	4	3
Nov.	53	30	46	12	13[3]	17	21	23	23	70	Trace	0.0	1	25	0	23	6	1	0
Dec.	59	37	50	5	7	14	16	17	30	72	0.45	0.30	1	30	0	22	6	3	2
	752	444	548	......	......	333	327	350	481	747	17.13	....	16	156	31	177	139	50	85
	63	37	46	......	......	28	27	29	40	68	....	....	......	......	......	......	......	......	......

[1] Yearly maximum. [2] Yearly minimum. [3] More than one date. [4] Thirty days. [5] Twenty-nine days. [6] One-hundredth of an inch or more.
[7] Recorded at the noon observation, unless otherwise noted. [8] At the 6 P. M. observation.

NOTES ON METEOROLOGICAL TOPICS.

BY F. H. LOUD.

I. Topography.

The State of Colorado, as is well known, consists in the eastern portion of plains, which rise by a gradual slope, interrupted by only slight prominences, and indented by the channels of streams, to the foothills which cluster about the base of the mountains. The line which separates these two very different regions, the plains and the mountains, is well marked, and the transition abrupt. Yet the plains are by no means uniform, and are separated into two natural divisions by the watershed, locally called the Divide, which parts the basins of the Platte and Arkansas rivers. The city of Colorado Springs is situated about five miles east of the foothills (nearly twelve miles east of the principal mountain, Pike's Peak,) and twenty-five miles south of the Divide, on a stream, the Monument, which flows southward from the latter, parallel to the line of the mountains, and joins the Fountain just below the city. The larger stream, the Fountain, breaks through the mountain wall in a defile, called the Ute Pass, which opens to the northwest of the town. After emerging upon the plains, the Fountain adopts substantially the course of its affluent, the Monument, flowing southward to meet the Arkansas at Pueblo. Thus the site of Colorado Springs is in a trough extending from north to south, and opposite the junction of a northwest to southeast channel of at least equal importance.

The central and older portion of the town is on a plateau composed of the granitic gravel from the mountain range, and lying between the Monument and a small tributary, Shooks Run. The principal slope is here to the south. The grounds of the college are on the upper, or northern, portion of this area, close to the Monument. The mountains—with Pike's Peak, nearly due west, in the middle of their line—occupy about 120° of the horizon, as seen from the neighborhood of the Observatory. The apparent elevation of the summit is about 7½°. The Ute Pass, on the north of the Peak, forms a noticeable notch in the mountain outline.

This topography exerts, of course, a marked influence upon the local meteorology, affecting particularly the direction of the wind, and through this the other elements of weather and climate. The air, when cooled, tends to drain off toward the south, while, on the other hand, a current passing down the Ute Pass is warmed by compression, and, under appropriate circumstances, develops into a strong wind, possessing striking qualities of high temperature and low humidity, and commanding general attention under the name of "chinook." But the effect of topography, aside from its manifestation in occasional and intermittent phenomena, is to be seen in the normal progression of wind movement, temperature, etc., from hour to hour through the day and night.

II. DIURNAL CHANGE OF ATMOSPHERIC CONDITIONS.

Four months of the year, separated by equal intervals,—January, April, July and October—have been selected to exhibit the diurnal changes, with the modifications of the latter brought about in the progress of the seasons. For each of these months, twenty-four tables—one for each hour—were drawn from the Daily Records, by transferring to one sheet the entries for that hour as found in the separate records of the successive days.

On account of the special interest of the statistics of wind, due to the local character of the phenomena, as well as their effect upon other elements of climate, this portion of the record is tabulated with greater fullness than the rest. First is presented the relative frequency with which the wind-direction, as indicated by the occurrence of positive or negative numbers in the volumes X and Y of the Daily Record, falls in the several quadrants. As the anemoscope record is not always complete, a column is added showing the number of days included in the comparison. This table depends on the indications of the vane alone, and is wholly unaffected by the varying strength of the different winds. It shows that S. W. winds are the most infrequent, while N. E. winds are next in order, exhibiting an ill-marked minimum about midnight, with a maximum, somewhat more distinct, from 8 to 10 a. m. But the great majority of the winds come either from the S. E. or the N. W. quadrant, the former claiming the warm hours near the middle of the day, while the latter dominates the rest of the day and all the night. On the whole, the northwest prevails over all competitors.

In the next table, the velocity of the wind is taken into account. The column of "Mean Velocity" presents the indications of the anemometer alone, without reference to direction, and shows the average number of miles of wind recorded in each hour of the day. This column reveals the occurrence—usual in all climates—of a maximum of velocity in the early afternoon, and a minimum in the night or early morning. Certain irregularities present themselves, which may be in part accidental, the extremes apparently occurring later in April and earlier in October than in the other months. The remaining columns of the table show the result of combining the observations of direction and velocity. They are the means from the two pairs of columns of "Velocity Resolved" in the Daily Record, showing the differences, N.—S. and W.—E. The positive and negative values of these differences are placed in separate columns. Here the superiority of the mid-day winds is entirely lost, in consequence of the conflict of opposing currents. The north and west are able in January to maintain their ascendency throughout the day, save for one hour in which the east overcomes the west, but in the other months the south and east prevail over their opponents for a considerable section of the period of daylight. At night, the control of the north and west winds —particularly the former—is undisputed.

The direction of the resultant from the two components of "Velocity Resolved" shows the point from which the force of the wind is on the whole exerted. It is given in the column headed "Resultant Bearing:"

The diurnal change in wind-direction, whether manifested in frequencies, components, or mean bearings, is evidently in close relation with the topography. At night the cooling of the air next the ground causes currents down the valleys, which flow like the streams of water, and in, or over the same channels. The movement being begun at the bottom, and guided by the lowest stratum, follows comparatively shallow depressions, and thus the south-bound stream over the Monument receives, and deflects into its own course, the stream from the northwest. In the day time, the draft up the valley is almost confined to the lofty flue afforded by the Pass.

At Denver, on the northern side of the Divide, the prevailing wind is from the south at all seasons of the year, though the strongest winds are frequently from a northerly quarter. This reversal of the prevailing direction at the two stations emphasizes the dependence of wind direction on topography.

The daily variation in the amount of possible sunshine—that is, the length of the visible arc of the sun's diurnal path —is, of course, shortened by the mountain chain in the west. The amount of this abridgment was determined with considerable care, and the results embodied in an article for "Colorado Weather" for April, 1889, which was reprinted in the "Studies" of last October. This table there given indicates the number of hours and minutes of "A. M. Sun" and "P. M.

Sun," the dividing point being the moment of apparent noon, as was convenient for comparison with the record of the photographic sunshine recorder formerly in use. The recorder connected with the quadruple register is set by ordinary clock time, hence it is more convenient with this instrument to know the mean time of sunrise and sunset, particularly the latter. The table, page 170, has accordingly been constructed by applying the mean equation of time for each date to the quantities comprised in the former table.

The diurnal change in the amount of sunshine, the pressure and temperature of the air, and the quantity of rainfall, are tabulated, page 167. In respect to the first of these (which is expressed in terms of the mean number of minutes in each hour during which the sun is shining), it will be remembered that the figures for July are derived from an entirely different instrument from those given for the other months, hence comparison between this month and the others should be made with caution, if at all. Nor is any conclusion to be based on the first one or two of the numbers contained in any sunshine column, on account of the irregularity of record previously explained. The morning hours, as a matter of ordinary observation, are usually cloudless, but they would not so appear from this table. The instrumental indications near the middle of the day are considered trustworthy, and the most certain result to be obtained from the tabulated figures—as also the most obvious—is the decline of sunshine in the summer afternoon, due to the formation of cumulus clouds.

The march of pressure, shown numerically in the next column, has been reduced to graphic form, and exhibits clearly the well-known double oscillation. The increased relative importance of the nocturnal wave in winter is strikingly shown. (See page 168.)

The daily change in temperature is also shown in a diagram, (page 169.) In both the charts, a broken line is used in platting the data for October, to avoid confusion with those of another month. It will be observed by the intersection of the curves that while April was a colder month than October in so far as the hours of daylight are concerned, the October nights from sunset to midnight were colder than those of the former month. This, in all probability, is to be attributed to the great clearness of the nights in autumn, the sky being frequently free from the least visible indication of vapor, and so allowing an uninterrupted radiation, which cools the ground and lower air.

To the same cause is probably to be attributed another peculiarity of the October curve—the slight rise of temperature during the night, resulting in a maximum about 3 a. m. When this was first noticed, the conjecture seemed plausible that it would be found to be due to chinook winds, which happened to begin to blow in the night; for two or three of the large and sudden rises of temperature which these winds are capable of producing would be sufficient, in the mean of only thirty-one days, to introduce an apparent maximum wholly foreign to the normal movement. On examination, however, it was found that while the omission of three days would indeed be very effective in smoothing the curve, the phenomenon was visible in a less degree on a large number of days in the month, while the three marked cases exhibited little of the chinook character, showing no agreement among themselves as regards the barometric conditions which usually operate in bringing on that wind. The recorded wind directions, also, for the hours in question exhibit no clear relation to the production of a nocturnal rise of temperature, while on the other hand the occurrence of such a rise seems to be favored by a slight accession of velocity.

It is likely that the real cause of this temperature-rise may be connected, as already suggested, with the rapidity of the fall which marks the first hours of the night. When the warmth of the air next the ground has been swiftly reduced by unimpeded radiation, the cooled stratum runs off in a current of moderate depth, and the air from above, not yet chilled in the same way, settles down, acquiring heat by compression during its descent. The tendency to a slight rebound of temperature, thus brought about, happened, in the month examined, to manifest itself with a sufficient regularity of hour to impress itself on the monthly means. In another year the same tendency might exist, without becoming evident in the same way. Thus in October, 1903, in the first eleven days of the month, there were seven instances in which an hourly mean of temperature, between midnight and sunrise, was higher than those of one or two preceding hours. But in the rest of the month this happened but seldom, and the means for the month of the hourly temperatures for the six hours after midnight exhibit the ordinary continuous descent, being 40.3°, 39.7°, 39.1°, 38.8°, 38.5°, 38.2°.

The last columns of the table shows the way in which the occurrence of rainfall was distributed through the day. This record by hours is limited to the warmer portion of the year, for reasons already stated. The July rainfall, which occurs almost wholly in thunder showers, is seen to be practically restricted to the afternoon. October presents a diminished prevalence of this summer type of rainfall, together with the beginning of a new one, shown in the fall of light showers in the night and early morning.

III. THE COLD WIND OF OCTOBER 24TH.

Although the sun is the source of practically all the heat of the atmosphere, yet it is matter of common observation that changes of temperature are very frequent, which appear to have little relation to solar influences. At night the curve traced by the thermograph is far from smooth, but often exhibits ten or a dozen rises and falls, which must be due to the action of the winds, though often so gentle as to excite no attention. Local differences of temperature occur in bodies of air at no great distance apart, in consequence of differences of exposure permitting more rapid radiation, or because the cooled air which in one place flows rapidly off, in another accumulates to a considerable volume before moving away in a body. Especially is this certain to be the case in a hilly or mountainous district. Here also is to be added the effect of expansion and compression, producing adiabatic cooling and heating in ascending and descending currents, whether these follow the inequalities of the ground, or mount and settle through the free air. Some instances of this nature have already been noticed in connection with the mean diurnal temperature curve of October (page 158.) The more sudden and violent changes are due to winds which are set in motion, not by local causes, but by the cyclonic storms affecting a broad extent of country. Sometimes these are warm winds, as in the case of the chinook; sometimes cold, as in the instance selected for remark in the present case. On October 24, 1904, a cold wind springing suddenly up, at the time when the return of morning normally brings on the chief rise of temperature for the day, overcame this rise altogether and substituted a fall, so that the hours before sunrise were warmer than any which succeeded, and the daily maximum was passed by 4 a. m. This wind was the advance attack of an anti-cyclone which was moving from the north to occupy Colorado and the adjacent states. Such occurrences are of meteorological interest in a mountainous district, from the opportunity there given to study the sequence of phenomena at different altitudes. The present instance was selected, not as of a specially typical character, but because of the circumstance that the writer happened to know of two parties who spent parts of this day at high altitudes, and who have kindly furnished him with memoranda concerning the weather conditions observed. Though the information was directly received from but one member of either party, it was prepared in each case in consultation with other members.

At the level of Colorado Springs, the night had been cloudless, with brilliant moonlight, and there was a light wind in the usual direction, down the Monument valley. Before sunrise, a curtain of cloud appeared in the north, the upper edge of which gradually rose, until, before the six o'clock observation, the entire sky was covered. With the appearance of the cloud, the wind suddenly increased in strength, springing at once to the velocity of twenty-six miles, while the barometer, which had been nearly stationary, began to rise. During the day this rise continued without interruption, and the thermometer steadily fell, as already mentioned, while the clouds continued to obscure the entire sky until after sunset, but cleared at night. The next day was of the usual high barometer type, the pressure showing no decline except at the diurnal minimum, the sky clear, the thermometer rising only to 48°, while two days before it had reached 70°. (For Oct. 24th, see Daily Record, page 127.)

The first of the parties of mountain-climbers just mentioned had gone into the hills on the 23d—the day of 70° temperature—for purposes of recreation, and spent the night at a level of about 9,000 feet, in a cabin situated in a branch canon, which has a steep slope toward the south, and opens a little below the cabin into a "park," or expansion of an eastward-sloping valley. In this position, the normal night wind is, of course, from the north, for the same reason as it is so at Colorado Springs. The night is described as "clear, crisp and cold,"—the latter adjective perhaps used in comparison with the weather of a lower level, for it is mentioned that in the morning there was no ice about the stream nor hoar frost on the ground. Sometime between 2 and 6 a. m., there was a noticeable increase in the strength of the wind, but this died down, and by 6 o'clock "all was quiet." This was four hours after the gale had begun blowing at the Springs, with a velocity most of the time exceeding twenty miles, so that the front of the cold wave at the lower level was fifty or perhaps more nearly a hundred miles in advance of its position 3,000 feet higher. At this time at Colorado Springs the sky was completely overcast, but in the canon the only clouds visible were light fringes upon some of the higher hills. The inference is that the canopy over the city did not reach the 9,000-foot level, even at the top.

"Within an hour of these observations," writes my informant, "the clouds increased and began to descend the hills, the atmosphere became markedly damper and apparently colder, and the ground and trees were slightly whitened with frost. We left the cottage at about 9 o'clock, wrapped in our warmest clothing, the cold being of such a penetrating nature. On our way down the clouds seemed to meet us, and the frost, to a slight extent, stuck to our clothing."

The second party to whose observations I am indebted was organized for scientific, though not for meteorological, purposes. Some of the physicians of the city, in co-operation with the professor of biology in Colorado College, took a company of college students to the summit of Pike's Peak to make tests of the effect of altitude on the blood. The party left Manitou at 8:45 October 24th, despite the threatening aspect of the weather at the lower end of the route, and were rewarded by a fine day on the mountain top. They passed into the clouds near the first stop on the way, which cannot have been higher than the (mis-called) "Halfway House," at an elevation of 8,913 feet. A little above Windy Point (12,233 feet) they left the clouds behind. They found on the summit a wind of low velocity, from the west and northwest. The temperature was agreeable and "felt much warmer than in Manitou or the Springs," partly, of course, from the direct effect of the sunshine. There was no noticeable change in weather conditions during their stay, which lasted until the middle of the afternoon, some five hours in all. The clouds furnished an impressive spectacle. They extended as far as the eye could reach, in surging billows, which swirled around to the south side of the mountain, where probably there was an eddy. At times they exposed the top of Cameron's Cone (10,700 feet) above their surface, and at other times reached an elevation but little below the top of the Peak (14,147 feet).

While it is unfortunate that no instruments, not even an ordinary thermometer, were carried by either party to ascertain quantitatively the atmospheric conditions, their observations indicate clearly one way in which an inversion of temperature may be produced. The occurrence of abnormally high temperatures at high elevations during an anti-cyclone is a phenomenon which has been regarded as theoretically significant. In the instance here described it seems clear that this phenomenon belonged to the initial stage of the local domination of the anti-cyclone, depending not so much on the operation of high-pressure conditions when established as on the process by which they were introduced into the neighborhood.

This process appears, from the similarity of phenomena, to have been essentially the ordinary one, as observed in this locality. It begins with a rather shallow flow of cold air from the north, driven by an excess of pressure in that direction. This runs beneath the comparatively quiet air of the region, much as a current of water would do, disturbing it but little, but lifting it bodily off the ground to a height which gradually increases as the volume of the underflow is enlarged. The barometer rises in virtue of the additional weight of the imported air, for the superincumbent strata, retaining their sluggish movement, do not run off at the top as fast as the new material is introduced below. Their moisture is condensed as the result of elevation, forming the thin stratum of cloud which regularly ushers in the anticyclone. This stratum is often dense enough to furnish a slight fall of snow, never a heavy one. On October 24th only a trace of precipitation was observed. The cloud stratum arrests the insolation which falls on its upper surface, and to this origin the warmth observed by the party on the Peak must be in part—perhaps may be altogether—attributed.

RELATIVE FREQUENCIES OF WIND-DIRECTION IN FOUR QUADRANTS.

TIME	JANUARY.					APRIL.				
	S. W.	N. W.	N. E.	S. E.	TOTAL	S. W.	N. W.	N. E.	S. E.	TOTAL
1 am	1	26	2	1	30	0	19	4	6	29
2 am	1	25	2	2	30	2	20	4	3	29
3 am	1	20	5	4	30	3	18	5	3	29
4 am	0	22	4	3	29	3	17	5	4	29
5 am	0	23	1	5	29	3	20	2	4	29
6 am	1	21	4	3	29	2	25	0	2	29
7 am	1	18	7	3	29	1	18	6	4	29
8 am	2	19	5	3	29	1	12	11	6	30
9 am	1	20	5	3	29	2	8	9	11	30
10 am	2	8	11	8	29	3	6	7	14	30
11 am	4	5	9	11	29	3	7	5	15	30
12 m	1	6	6	18	31	6	6	5	13	30
1 pm	2	6	8	15	31	5	7	3	15	30
2 pm	2	6	8	15	31	5	7	4	14	30
3 pm	2	11	5	13	31	2	9	3	16	30
4 pm	1	11	7	12	31	4	9	2	15	30
5 pm	2	13	5	11	31	4	8	4	14	30
6 pm	1	15	9	4	29	4	11	2	13	30
7 pm	2	17	7	3	29	2	10	3	13	28
8 pm	1	19	7	2	29	3	12	3	10	28
9 pm	0	21	6	2	29	1	13	5	9	28
10 pm	2	18	5	4	29	2	13	5	9	29
11 pm	3	18	6	2	29	3	14	2	10	29
12 n't	3	22	4	1	30	0	20	2	7	29

TIME	JULY.					OCTOBER.				
	S. W.	N. W.	N. E.	S. E.	TOTAL	S. W.	N. W.	N. E.	S. E.	TOTAL
1 am	1	17	9	4	31	1	26	0	4	31
2 am	2	24	3	2	31	0	24	1	6	31
3 am	2	23	2	4	31	1	23	4	3	31
4 am	0	25	4	2	31	1	23	2	5	31
5 am	0	22	8	1	31	2	26	0	3	31
6 am	1	25	5	0	31	1	24	2	3	30
7 am	0	21	9	1	31	2	22	4	3	31
8 am	0	16	10	5	31	2	20	7	2	31
9 am	3	9	9	10	31	1	16	8	6	31
10 am	2	10	3	16	31	1	7	10	13	31
11 am	0	3	8	20	31	2	3	9	17	31
12 m	0	3	6	22	31	1	4	5	21	31
1 pm	1	5	3	22	31	1	1	10	19	31
2 pm	1	5	8	17	31	2	3	7	19	31
3 pm	5	7	7	12	31	3	2	6	20	31
4 pm	4	7	5	15	31	2	7	2	20	31
5 pm	5	11	3	12	31	5	6	2	18	31
6 pm	4	11	3	13	31	6	7	2	16	31
7 pm	6	15	2	8	31	1	16	6	8	31
8 pm	1	17	3	10	31	0	21	5	5	31
9 pm	6	16	4	5	31	0	24	4	3	31
10 pm	4	19	3	5	31	0	26	4	1	31
11 pm	4	16	8	2	30	0	26	2	3	31
12 n't	1	18	7	5	31	0	23	5	3	31

MEAN DAILY WIND MOVEMENT.

JANUARY.						APRIL.					
Mean Veloc'y	N. +	S. −	W. +	E. −	Resultant Bearing	Mean Veloc'y	N. +	S. −	W. +	E. −	Resultant Bearing
8.6	6.4	....	3.5	....	N. 28° 13′ W.	9.8	5.3	....	2.2	....	N. 22° 22′ W.
7.5	5.9	....	2.7	....	N. 24° 36′ W.	9.6	5.3	....	2.4	....	N. 24° 32′ W.
6.3	4.4	....	1.5	....	N. 18° 17′ W.	9.0	4.7	....	2.6	....	N. 29° 19′ W.
7.4	4.4	....	1.3	....	N. 16° 44′ W.	9.4	5.5	....	2.1	....	N. 20° 29′ W.
7.0	4.4	....	0.9	....	N. 10° 51′ W.	8.4	5.1	....	1.9	....	N. 20° 54′ W.
7.4	5.4	....	0.8	....	N. 8° 58′ W.	8.3	5.7	....	2.1	....	N. 20° 03′ W.
6.8	5.2	....	0.8	.	N. 8° 28′ W.	8.3	4.5	....	0.6	....	N. 8° 02′ W.
9.3	5.5	....	0.5	....	N. 4° 50′ W.	7.5	4.2	....	....	0.5	N. 6° 51′ E.
9.0	4.9	....	0.8	....	N. 9° 05′ W.	8.6	2.7	....	....	0.3	N. 7° 02′ E.
8.2	3.0	....	0.2	....	N. 4° 40′ W.	11.5	1.3	....	....	0.3	N. 10° 54′ E.
9.0	1.3	....	....	0.9	N. 33° 47′ E.	13.3	....	0.1	0.1	....	S. 46° 47′ W.
10.7	0.5	....	0.0	....	N. 0° 00′	13.4	....	0.2	0.6	....	S. 69° 52′ W.
11.9	1.9	....	1.0	....	N. 27° 24′ W.	15.2	....	1.3	1.0	....	S. 35° 36′ W.
13.1	2.6	....	1.1	....	N. 22° 29′ W.	15.7	....	1.2	0.8	....	S. 33° 11′ W.
12.4	3.6	....	2.4	....	N. 33° 03′ W.	16.7	....	0.9	2.8	....	S. 72° 54′ W.
12.3	4.4	....	1.5	....	N. 18° 26′ W.	16.4	....	1.0	2.0	....	S. 62° 17′ W.
10.1	4.6	....	1.9	....	N. 22° 09′ W.	17.0	....	1.1	2.3	....	S. 64° 06′ W.
9.1	5.6	....	2.6	....	N. 24° 22′ W.	14.4	1.0	....	1.8	....	N. 59° 46′ W.
9.7	6.7	....	4.2	....	N. 32° 21′ W.	11.2	1.4	....	0.8	....	N. 31° 22′ W.
8.2	6.7	....	2.6	....	N. 21° 25′ W.	10.4	3.0	....	1.3	....	N. 22° 51′ W.
8.7	6.8	....	3.1	....	N. 24° 27′ W.	9.8	3.4	....	0.7	....	N. 12° 00′ W.
7.3	4.5	....	2.5	....	N. 29° 20′ W.	10.2	4.4	....	1.2	....	N. 15° 34′ W.
8.0	4.8	....	2.6	....	N. 28° 08′ W.	9.4	4.0	....	2.2	....	N. 28° 44′ W.
8.0	5.2		2.9	.	N. 29° 12′ W.	9.4	4.4	....	2.2	....	N. 26° 21′ W.
216.0	108.7		41.4	0.9		272.9	65.9	5.8	33.7	1.1	

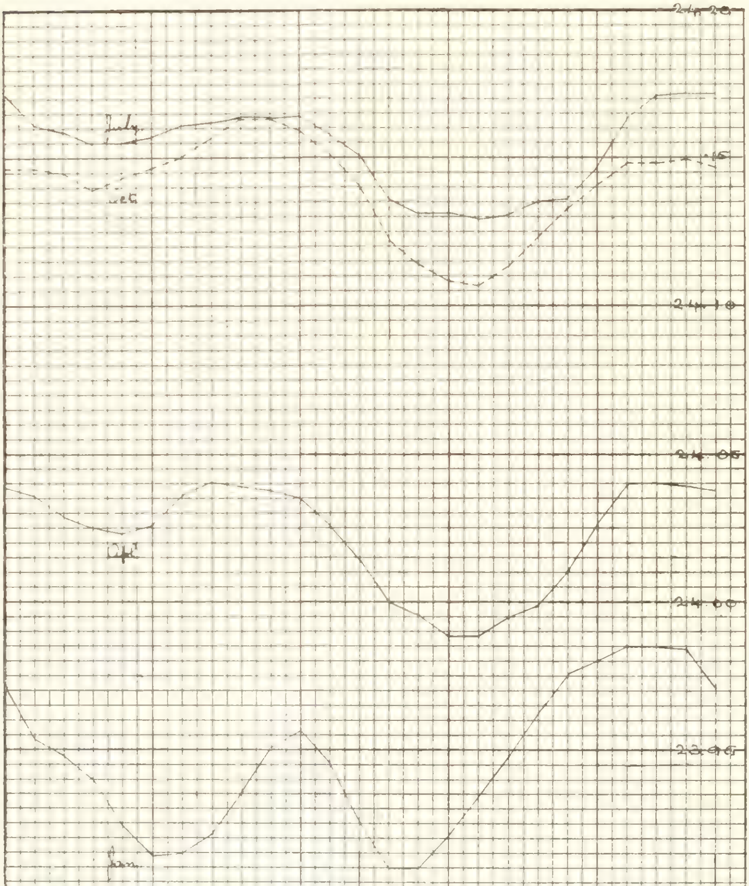
JULY.						OCTOBER.					
Mean Veloc'y	N. +	S. −	W. +	E. −	Resultant Bearing	Mean Veloc'y	N. +	S. −	W. +	E. −	Resultant Bearing
4.8	3.5	....	0.5	....	N. 8° 04′ W.	8.0	5.9	....	1.9	....	N. 17° 48′ W.
4.8	3.5	....	0.9	....	N. 13° 55′ W.	7.6	5.5	....	1.0	....	N. 10° 04′ W.
4.5	3.6	....	0.7	....	N. 10° 19′ W.	7.6	5.5	....	1.6	....	N. 16° 12′ W.
5.2	4.6	....	0.8	....	N. 9° 37′ W.	8.4	5.9	....	1.0	....	N. 9° 50′ W.
5.5	4.8	....	0.6	....	N. 7° 26′ W.	8.0	5.9	....	1.8	....	N. 17° 02′ W.
5.8	4.7	....	1.2	....	N. 14° 37′ W.	7.5	5.3	....	1.0	....	N. 10° 52′ W.
5.8	5.0	....	0.7	....	N. 12° 00′ W.	7.1	5.8	....	1.1	....	N. 10° 20′ W.
5.3	3.3	....	0.3	....	N. 5° 36′ W.	7.0	5.6	....	1.3	....	N. 13° 28′ W.
6.2	1.7	....	....	0.6	N. 20° 00′ E.	5.7	3.7	....	0.3	....	N. 5° 10′ W.
7.0	....	3.0	....	1.5	S. 79° 19′ E.	6.5	1.8	....	....	1.9	N. 45° 21′ E.
7.8	....	1.3	....	3.4	S. 69° 45′ E.	8.4	....	0.8	....	3.0	S. 75° 46′ E.
8.6	....	2.1	....	4.1	S. 62° 49′ E.	8.9	....	1.2	....	3.5	S. 70° 22′ E.
8.9	....	3.9	....	3.7	S. 43° 36′ E.	9.4	....	1.2	....	3.8	S. 73° 06′ E.
9.1	....	1.8	....	3.2	S. 60° 29′ E.	8.9	....	1.6	....	4.0	S. 68° 21′ E.
10.9	0.3	....	....	1.6	N. 78° 32′ E.	9.4	....	2.8	....	3.4	S. 50° 51′ E.
11.0	0.8	....	....	2.0	N. 66° 47′ E.	8.8	....	2.7	....	2.5	S. 43° 18′ E.
9.4	0.0	....	....	1.1	N. 87° 41′ E.	7.6	....	2.9	....	2.0	S. 34° 55′ E.
8.2	....	0.7	....	0.9	S. 51° 54′ E.	5.6	....	1.6	....	0.7	S. 24° 17′ E.
7.4	0.2	....	1.3	....	N. 80° 46′ W.	5.5	1.6	....	0.0	....	N. 0° 36′ W.
6.4	2.3	....	1.2	....	N. 26° 38′ W.	5.8	3.9	....	0.0	....	N. 0° 34′ W.
6.5	2.4	....	1.7	....	N. 35° 30′ W.	6.0	4.5	....	0.9	....	N. 12° 00′ W.
6.3	3.3	....	2.1	....	N. 33° 06′ W.	6.2	5.1	....	0.7	....	N. 7° 28′ W.
5.5	3.1	....	1.3	....	N. 22° 31′ W.	6.9	5.5	....	0.6	....	N. 6° 28′ W.
5.1	3.8	....	0.3	....	N. 4° 37′ W.	7.1	5.8	....	0.3	....	N. 3° 18′ W.
166.0	50.9	12.8	13.6	22.1		177.9	77.3	14.8	13.5	24.8	

MEAN DAILY MARCH OF ATMOSPHERIC CONDITIONS.

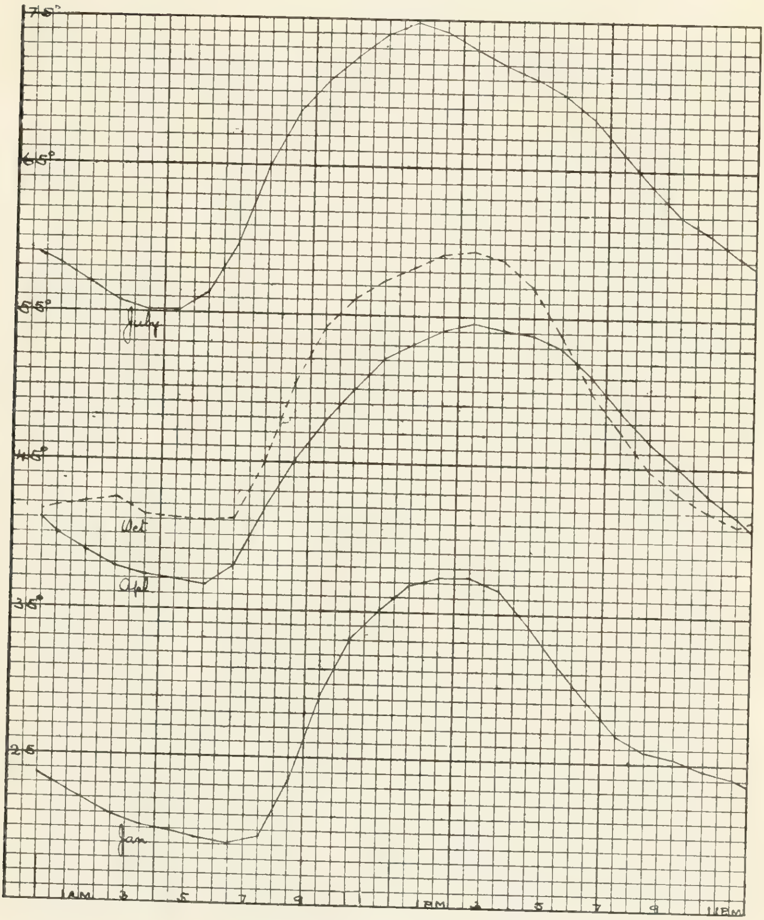
Hour Ending.	January.				April.				July.				October.			
	Sun.	Barom.	Therm.	Total Rain.	Sun.	Barom.	Therm.	Total Rain.	Sun.	Barom.	Therm.	Total Rain.	Sun.	Barom.	Therm.	Total Rain.
1 A. M.	......	23.953	23.2	......	......	24.036	40.0	......	......	24.162	58.3	......	......	24.147	41.9	......
2 "	......	.948	21.8	......	......	.028	38.9	......	......	.159	57.1	......	......	.145	42.2	.01
3 "	......	.939	21.0	......	......	.025	37.9	......	......	.155	55.8	......	......	.139	42.4	......
4 "	......	.924	20.3	......	......	.023	37.4	......	......	.155	55.2	......	......	.143	41.5	.01
5 "	......	.914	19.9	......	......	.026	37.0	......	......	.157	55.2	......	......	.147	41.2	.01
6 "	......	.915	19.4	......	0.2	.036	36.7	......	20.8	.161	56.5	......	......	.150	41.0	.01
7 "	......	.922	19.1	......	21.7	.041	38.2	......	49.2	.162	60.0	......	......	.157	41.1	......
8 "	1.1	.936	19.6	......	33.6	.039	41.8	......	52.3	.164	65.2	......	21.5	.163	45.0	......
9 "	42.4	.951	23.6	......	41.7	.038	45.1	.06	54.4	.163	68.6	......	45.2	.163	50.4	......
10 "	51.3	.957	29.2	......	46.3	.035	47.8	.05	52.8	.164	70.8	......	48.6	.159	54.3	......
11 "	53.7	.946	33.2	......	48.7	.025	50.0	......	52.9	.158	72.5	......	50.5	.152	56.1	......
12 "	52.7	.925	35.2	......	47.7	.013	52.2	......	47.0	.151	74.0	.31	49.0	.139	57.4	......
1 P. M.	51.4	.910	36.9	......	50.0	.000	53.2	......	38.1	.136	74.7	.17	47.1	.122	58.4	......
2 "	52.3	.910	37.4	......	48.6	23.996	54.1	......	28.9	.132	74.3	.03	47.2	.114	59.2	......
3 "	51.1	.921	37.4	......	47.5	.988	54.6	......	23.0	.132	73.1	.56	43.9	.108	59.4	......
4 "	39.5	.934	36.6	......	38.4	.988	54.2	......	24.0	.129	72.0	.26	40.9	.107	58.8	.05
5 "	10.7	.948	34.2	......	37.9	.995	53.9	......	22.6	.131	71.2	.71	13.7	.113	56.9	.06
6 "	......	.963	31.5	......	21.9	.998	53.0	......	14.3	.135	70.1	.75	......	.123	53.6	.07
7 "	......	.976	29.2	......	1.0	24.011	51.0	......	8.6	.136	68.4	.14	......	.133	49.9	.04
8 "	......	.980	26.9	......	......	.027	48.7	......	......	.147	66.1	.05	......	.141	47.3	......
9 "	......	.985	25.9	......	......	.040	46.7	......	......	.163	63.9	.04	......	.148	44.9	......
10 "	......	.985	25.4	......	......	.040	45.0	......	......	.171	62.0	.04	......	.148	43.4	.01
11 "	......	.984	24.7	......	......	.039	43.3	......	......	.172	60.8	......	......	.149	42.2	......
12 "	......	.971	24.3	......	......	.038	41.9	.01	......	.172	59.3	......	......	.147	41.3	......
				*.11				*.11				*.04				
Sums,	406.2	574.697	655.9	0.11	485.2	576.525	1102.6	0.23	488.9	579.667	1565.1	3.10	407.6	579.357	1169.8	0.27
Means,	......	23.945	27.3	......	......	24.022	45.9	......	......	24.152	65.2	......	......	24.140	48.7	......

* Not included in hourly register.

DIURNAL CURVES OF PRESSURE.



DIURNAL CURVES OF TEMPERATURE.



TIME OF SUNRISE AND SUNSET AT COLORADO SPRINGS.*

January.			February.			March.		
Date.	Sun-rise.	Sun-set.	Date.	Sun-rise.	Sun-set.	Date.	Sun-rise.	Sun-set.
1	7 24	4 13	2	7 10	4 42	2	6 35	5 17
3	7 24	4 14	4	7 8	4 44	4	6 32	5 19
5	7 24	4 16	6	7 5	4 46	6	6 29	5 21
7	7 24	4 17	8	7 3	4 48	8	6 26	5 24
9	7 23	4 18	10	7 0	4 51	10	6 23	5 25
11	7 23	4 19	12	6 59	4 53	12	6 20	5 26
13	7 23	4 21	14	6 56	4 53	14	6 17	5 28
15	7 22	4 23	16	6 54	4 56	16	6 14	5 35
17	7 21	4 24	18	6 51	5 0	18	6 10	5 36
19	7 20	4 26	20	6 49	5 4	20	6 7	5 36
21	7 19	4 29	22	6 47	5 6	22	6 4	5 38
23	7 18	4 31	24	6 43	5 10	24	6 1	5 38
25	7 17	4 34	26	6 41	5 11	26	5 58	5 38
27	7 15	4 35	28	6 38	5 13	28	5 55	5 40
29	7 13	4 37				30	5 51	5 46
31	7 12	4 40						

April.			May.			June.		
Date.	Sun-rise.	Sun-set.	Date.	Sun-rise.	Sun-set.	Date.	Sun-rise.	Sun-set.
1	5 49	5 50	1	5 6	6 28	2	4 41	6 58
3	5 45	5 53	3	5 4	6 31	4	4 40	6 59
5	5 43	5 56	5	5 2	6 32	6	4 39	6 59
7	5 39	5 58	7	4 59	6 35	8	4 39	7 1
9	5 37	6 1	9	4 57	6 39	10	4 39	7 1
11	5 33	6 5	11	4 55	6 42	12	4 39	7 2
13	5 30	6 6	13	4 53	6 45	14	4 39	7 2
15	5 28	6 10	15	4 52	6 46	16	4 39	7 2
17	5 24	6 11	17	4 50	6 46	18	4 39	7 3
19	5 22	6 13	19	4 48	6 47	20	4 39	7 4
21	5 20	6 16	21	4 47	6 48	22	4 40	7 5
23	5 16	6 18	23	4 46	6 51	24	4 40	7 4
25	5 14	6 22	25	4 45	6 53	26	4 42	7 5
27	5 12	6 26	27	4 43	6 54	28	4 42	7 5
29	5 8	6 27	29	4 42	6 56	30	4 42	7 5
			31	4 41	6 57			

*By sunset is here meant the disappearance of the sun's upper limb behind the mountain line, as seen from a point near the Observatory.

TIME OF SUNRISE AND SUNSET AT COLORADO SPRINGS.
(Continued.)

July.			August.			September.		
Date.	Sun-rise.	Sun-set.	Date.	Sun-rise.	Sun-set.	Date.	Sun-rise.	Sun-set.
2	4 44	7 6	1	5 6	6 50	2	5 35	5 57
4	4 45	7 5	3	5 8	6 46	4	5 36	5 53
6	4 45	7 5	5	5 9	6 43	6	5 38	5 50
8	4 47	7 6	7	5 11	6 40	8	5 40	5 45
10	4 48	7 5	9	5 12	6 37	10	5 42	5 42
12	4 49	7 5	11	5 15	6 35	12	5 43	5 34
14	4 51	7 5	13	5 17	6 33	14	5 45	5 29
16	4 53	7 3	15	5 18	6 30	16	5 47	5 27
18	4 54	7 1	17	5 20	6 27	18	5 49	5 25
20	4 55	6 59	19	5 21	6 21	20	5 50	5 23
22	4 57	6 58	21	5 24	6 17	22	5 53	5 22
24	4 59	6 56	23	5 25	6 15	24	5 54	5 19
26	5 0	6 56	25	5 27	6 14	26	5 56	5 15
28	5 2	6 55	27	5 29	6 9	28	5 58	5 9
30	5 4	6 53	29	5 31	6 6	30	6 0	5 6
			31	5 32	6 2			

October.			November.			December.		
Date.	Sun-rise.	Sun-set.	Date.	Sun-rise.	Sun-set.	Date.	Sun-rise.	Sun-set.
2	6 1	5 3	1	6 32	4 18	1	7 5	4 0
4	6 4	5 0	3	6 35	4 14	3	7 7	4 0
6	6 5	4 58	5	6 37	4 13	5	7 9	4 1
8	6 8	4 55	7	6 39	4 11	7	7 11	4 1
10	6 9	4 51	9	6 41	4 9	9	7 13	4 1
12	6 11	4 46	11	6 43	4 8	11	7 14	4 2
14	6 13	4 44	13	6 45	4 6	13	7 15	4 1
16	6 15	4 41	15	6 48	4 6	15	7 16	4 2
18	6 17	4 37	17	6 50	4 4	17	7 18	4 3
20	6 19	4 33	19	6 53	4 4	19	7 19	4 3
22	6 22	4 30	21	6 54	4 2	21	7 20	4 4
24	6 23	4 27	23	6 57	4 2	23	7 21	4 6
26	6 26	4 23	25	6 59	4 0	25	7 22	4 7
28	6 28	4 23	27	7 1	4 0	27	7 22	4 8
30	6 30	4 19	29	7 3	4 0	29	7 23	4 10
						31	7 23	4 11

THE EVOLUTION OF THE SNOW-CRYSTAL.

By John C. Shedd.

The snow-crystal, solidifying, as it does from the vapor of the atmosphere, is formed under circumstances exceptionally favorable to freedom of movement of the molecules. This fact accounts, no doubt, for the great variety of crystal form observed, a variety not approached by any other mineral. It is, however, not so clear as to what determines the formation of one or other of the various types.

The most discriminating classification of snow crystals is that given by Hellmann in 1893 (*Note 1*) and is briefly as follows:

I. Tabular forms: i. e., those where the ratio of thickness to diameter is less than .1.

1. Fern stellar (fig. 3).
2. Solid tabular (fig. 1).
3. Combinations of both (fig. 2).

II. Columnar forms, i. e., those in which the ratio of thickness to diameter is greater than 1 and less than 5.

1. Prismatic.
2. Pyramidal.
3. Combinations of Columnar and tabular forms (fig. 1).

Bentley (*Note 2*) gives a slightly different classification, as follows:

1. Columnar (fig. 1).
2. Solid tabular (fig. 1).
3. Stellar nucleus (fig. 2).
4. Fern-stellar (fig. 3).
5. Doublets (fig. 4).
6. Needle-shaped (fig. 5).
7. Granular (fig. 6).

Of these, the 1st, 5th and 6th belong to the columnar classification of Hellmann, while the rest are tabular excepting as the granular are to be classed by themselves. In this connection, Bentley remarks: "It is to be noted that there are other forms whose structures entitle them to be considered as distinct types but they occur so rarely that they will not be considered."

An important part of Mr. Bentley's work (*Note 2*) is contained in the tables he gives showing the distribution of the various types of crystals with respect to:

(1) Storm section, (2) temperature, and (3) cloud source.

These tables are summarized in the following tables with the modification that instead of the actual number of occurrences of each type the per cent. number is given. In this way the relative distribution of the types is shown.

TABLE I.

Distribution of snow-crystals of various types for 131 general Vermont storms, years 1897 to 1902.

STORM SECTION.	Columnar. (1)	Solid Tabular. (2)	Stellar Nucleus. (3)	Fern Stellar. (4)	Doublets. (5)	Needle Shaped. (6)	Granular. (7)
	%	%	%	%	%	%	%
N.	22	19	25	17	3	6	8
N. E.	14	19	24	10	14	5	14
E.	22	11	15	26	4	11	11
S. E.	25	25	25	25	0	0	0
S.	0	5	10	40	5	10	26
S.W.	13	16	19	23	8	3	18
W.	9	21	25	22	5	5	13
N.W.	5	20	23	22	7	22	20
Central	12	13	18	19	13	8	17
Undetermined	8	16	26	20	0	2	26
Distribution for 14 local storms, 1901–02	7	0	13	27	0	0	53
Grand total for all cases	11	16	21	23	4	5	20

TABLE II.

Distribution of crystals with respect to temperature. (*Bentley.*)

	Columnar. (1)	Solid Tabular. (2)	Stellar Nucleus. (3)	Fern Stellar. (4)	Doublets. (5)	Needle Shaped. (6)	Granular. (7)
	%	%	%	%	%	%	%
Medium cold storms, +15 F. to +5 F.	23	20	17	14	5	3	20
Very cold storms, +5 F. to -10 F.	10	22	26	23	5	4	11

Prof. Hellmann (*Note 3*) cites figures for the three types, fern-stellar, stellar-nucleus and solid tabular. Taking these types by themselves, the following table results:

TABLE III.

TEMPERATURE.	Solid Tabular (2)	Stellar Nucleus. (3)	Fern Stellar. (4)	Number of Cases.	OBSERVER.
	%	%	%		
21.2 F. to 18.5 F.	26	22	52	31	Tissandier (Paris)
15.8 F. to 9.5 F.	57	19	24	21	
Totals	41	18	41	52	
15 F. to 5 F.	40	34	28	39	Bentley (Vermont)
5 F. to —10 F.	30	37	33	47	
Totals	34	35	31	88	
Totals for both	36	30	34	144	

TABLE IV.

Distribution of crystals with respect to cloud sources during 67 storms, winter of 1901-02. (*Bentley.*)

CHARACTER OF CLOUDS.	Columnar. (1)	Solid Tabular. (2)	Stellar Nucleus. (3)	Fern Stellar. (4)	Doublets. (5)	Needle Shaped. (6)	Granular. (7)
	%	%	%	%	%	%	%
Cumulo-nimbus	2	0	15	35	0	7	41
Stratus and nimbus	20	13	20	27	13	6	0
Cirro-stratus and nimb.	6	16	20	20	4	6	28
Cirro-cumulus	0	0	0	0	0	0	0
Stratus	16	33	33	0	0	0	16
Cirrus	0	0	0	0	0	0	0
Cirro-stratus	32	23	23	18	0	5	0
Cirrus and cumulus	11	11	22	22	11	0	22

In considering the foregoing tables, the following remarks of Mr. Bentley should be carefully noted: "It will be noted that the cirrus and cirro-cumulus clouds have deposited no snow-crystals. These clouds, when occurring alone, very rarely, if ever, deposit crystals of sufficient size to fall to the earth. . . . When nimbus or stratus clouds are present the existence of cloud strata lying above the lower clouds can not be certainly determined, but have been inferred from general considerations. In general the snow forms are most frequent when two or more cloud strata exist. . . .

"In general there are present two great cloud divisions, lower and upper. The lower clouds are drifting spirally inward toward the storm's center: the upper clouds, which often extend outward far beyond the lower clouds and the area of precipitation, are drifting outward away from the storm center. Within the central regions of the storm, and also within detached portions of the outer regions, the ascension and horizontal expansion of the lower clouds form vast masses of intermediate and upper clouds. In the eastern and southern regions the upper clouds flowing outward, or more nearly with the average eastward drift of the whole atmosphere in our latitudes, naturally move fastest, and extend farther outward than do such clouds within the other segments of the storm. The relatively warm moist air flowing horizontally inward below these upper clouds, does not usually ascend in mass, until it approaches the storm's center: hence the lower cloud strata within these segments are inconsiderable, consisting usually of but small detached masses of swiftly-moving nimbus clouds. . . .

"Within the northern segments of a storm the relatively cold in-flowing lower air will be heavier, and will not exhibit as strong a tendency to ascend as do similar lower currents within other portions of the storm: hence the production of snow crystals will usually be much less here than elsewhere. . . .

"The clouds within the western segment of the storm are not likely to differ greatly from the northern, except in so far as the lower ones exhibit a stronger tendency to ascend, and so far as overhanging upper clouds are sometimes absent. . . .

"We have now but to consider the central portions of general storms. We may conclude with much certainty that the convergence of large bodies of moist air, either warm or cold, cause its general and often violent ascension at the center. The ascent of this body of vapor-laden air around the storm center, especially in its southwest and central portions, causes the formation of immense continuous cloud masses, reaching from the lower clouds up to, and merging into and forming, both intermediate and upper strata."

A study of the foregoing tables leads to the following conclusion:

1. The fern-stellar, or open structure, type of crystal is on the whole of the most frequent occurrence. In this connection Mr. Bentley says: "The preponderance of the branching open structure crystals and granular forms will be noted, and it may be added that such types actually form a larger percentage of the total mass of crystals than is indicated by the figures."

2. They are numerous in the case of local storms; in general storms they seem to be the most numerous in the southern segment.

3. They are more frequent in the case of storms of low temperature than when the temperature is higher.

4. They are frequent in the case of low-lying clouds.

5. On the other hand, the crystals with solid centers are most frequent in the case of high-lying clouds. At cold

temperatures these classes gain at the expense of the granular type.

6. The granular type occurs frequently when the temperature is high and in local storms; it is not frequent at low temperatures.

7. The doublets and needle-shaped crystals are infrequent at best and occur equally at all temperatures; double cloud strata seem to be favorable to their production.

SNOW STORM RECORD FOR WINTER OF 1901-2.

[In considering this record, it should be remembered that Colorado Springs is situated just east of a high range rising from 4,000 to 8,000 feet above the level of the city.]

November 17-18—Snow fell during night; light west wind, maximum velocity, 5 miles per hour; temperature about 32° F., snow—granular pellets.

December 7—Snow. 8:45 a. m. to 1 p. m. Low area centered in S. W. Colorado. "Granular."

December 11-12—Began during the night preceding 11th, ended 4 p. m. 12th. Low in Arizona and New Mexico. On the 11th: Early a. m. granular; 9 a. m., crystalline, sizes, one-thirty-second to one-sixteenth inch; crystals of open "fern stellar" and "stellar nucleus" types. On the 12th: snow, fine and drifting, granular.

December 16—Began 8:30 a. m. Ended during night. Low barometer in Eastern Nebraska and Kansas. High area west of the mountains, pushing eastward during the day. Day began cloudy, no wind. At 8 a. m. light wind from W. and N. W. Snow granular and fine. Temperature near freezing point, and falling. Temperature fell all day. No crystals.

December 17—Previous night clear. Frost crystals in morning abundant, amounting to a light, fluffy snow. Crystals *all* of open "fern stellar" types, large and beautifully symmetrical; size, large, ⅜-inch in diameter. Temperature 6 a. m., 2° F., relative humidity 6 a. m., 95%.

December 19—Began during night, ended 4 p. m. High barometer far in the north. Principal low area S. W. of California, but indications of a subordinate center in W. Wyoming. During previous night became cloudy; at about 3 a. m. began to snow. Flakes small, crystalline, with granular coatings. Structure close. The fall of snow was light. In the morning there was a light, fluffy fall of "Frost" snow (See Dec. 17); crystals large and of open "fern stellar" type. During the a. m., the temperature being from 26° to 30°, there were flakes flying, small, compact, crystals of the "solid tabular" type. Wind light from north. Clouds low, hanging, nimbus. During p. m., wind west, light, temperature about 31°, clouds cumulus. Flakes of snow fell in flurries; crystals as in a. m., but larger and more elaborate, being of the "fern stellar" type.

December 24—From 5:30 a. m. to 6 p. m. This snow fall followed the chinook wind of the 23d, which, blowing down the mountains, produced the maximum temperature of the month, together with a dryness much below the average. The impulse to this wind was an area of high barometer just behind the mountains, centered at the S. W. corner of Colorado. By the 24th, this anti-cyclone seems to have spent itself, and a low area formed eastward, about Oklahoma. The wind was reversed in direction, and the snowfall followed in consequence. Wind in north at about 9 a. m., granular snow began, changing later to small "solid tabular" and then to the layer "fern stellar" and more elaborate types. Clouds nimbus, temperature near 32°. The storm cleared in about an hour, but was rather thick while it lasted.

The month of December, while by no means so uniformly free from clouds and cold winds as November was, nevertheless on the whole left the impression of a warm and pleasant month for the season, the snowfall being in no instance of more than an insignificant amount, and never remaining long on the ground.

January 17—Upon this date a region of moderately high barometer, having clear skies in the center, but fringed with cloud and snowfall all along the edge, advanced rapidly eastward across the mountains. The station barometer, which had reached a minimum in the early morning, rose slowly during the day. Snow fell from just before noon to half past two. Clear in a. m. Wind in W. and N. W. light—cloud over Pike's Peak. This cloud grew and settled down over the mountains. At 11:30 high N. W. wind arose, bringing heavy fall of snow. Flakes were aggregations of smaller ones, but no granulations or crystals. Later flakes became smaller—no crystals. Temperature about 32°. General storm—clouds nimbus.

January 20—A low area in northern Texas was surrounded by a very considerable region of cloud and snowfall, mostly, however, to the east of our station. Snow fell here in short squalls between 11:30 a. m. and 5 p. m. Snow flurry, 8 to 9 a. m., no crystals; flakes small and fine. Flurry in p. m., flakes large.

January 22—Moderately low pressures occurred over the highlands to the south; high to the north, with a line of snowfall extending from Pueblo to Duluth and clouds eastward to and beyond the Mississippi. Toward evening the clouds settled down from the mountains—little or no wind. Snow began at 10 p. m., very fine, not granular or crystalline. Snow continued during night, wind E. or S. E., very light. Appearance of snow the same in morning as the night before. As this fall occurred after the evening observation, it is tabulated under the date of the 23d.

January 23—During the forenoon till 10 o'clock a little fine snow was flying. At this time a S. E. wind rose, bringing quite a flurry of snow. The flakes were small, not over a thirty-second of an inch, and of great variety. Doublets were abundant, some with both ends of the same size, some of different sizes. A few had a disc in the middle of the bar. Some bars had no ends; and one flake consisted of (eight?) radiating tubes or bars, for under the microscope the bars were seen to be hollow hexagonal tubes. (*Note 4.*)

This snowfall inaugurated the cold week, which formed the first touch of cold weather since New Year. There was another small fall during the night of the 24th-25th, and a still less important one in the forenoon of the 29th. The week was characterized by violent changes in the general weather map, a cyclone of 29.5 over Utah and Colorado, on the morning of the 26th, giving place by the 27th to a high barometer (30.7 inches) centrally located—near Kansas City—and dominating the entire area of the U. S.

February 3 and 4—The anti-cyclone formed on the plateau, to the westward, crossed the mountains, developing the greatest cold of the month, and followed by a little snow. Light snow overnight, fluffy frost-snow in morning. There were large branching open crystals, "fern stellar" type; some were compact and small. Under the microscope there seemed to be some doubles resembling the form of a collar button.

February 12 and 13—A region of high barometer was formed on the morning of the 12th on the Pacific coast, and another in Dakota, extending southward to Kansas City. Over the mountains the pressure was slightly below normal, the lowest point being at the extreme north. Under these conditions the general movement of the air as indicated by the majority of the wind observations of Colorado and vicinity, was down the eastward slope of the mountains. This movement probably helped toward the attainment on the 12th of the maximum temperature at Colorado Springs. The point of lowest barometer then shifted to the south end of the trough over the mountains, and the snow followed upon the reversal of the direction of the currents. About noon clouds settled over the Peak and down from the mountains. At 2:30 p. m. a southeast wind brought a fall of snow. The flakes were large aggregations of tabular flat crystals. These were open "fern-stellar" crystals. By 3 or 3:30 p. m. the wind had shifted to the northwest and blew quite strongly, the fall of snow was heavy. Flakes crystalline with granulations. As the storm progressed many crystals of different sizes were intermingled, having no granular coatings.

February 18 and 19—An area of low barometer, with high both to eastward and westward, made its way from the British Pacific colonies southeastward to the Gulf of Mexico —it was accompanied by extensive cloudiness and moderate precipitation. Snow during night of 17-18, not heavy. During a. m. more or less snow, no crystals. Wind east and southeast. At about 4 p. m., wind shifted to north, snow fell in large flakes, composed in many cases of tabular crystals. By 10 p. m. (18th), wind had freshened and snowfall increased. The flakes presented crystals of great variety, all, so far as seen, tabular. Regular hexagonal forms—large open structure ("fern stellar"), small and compact ("solid tabular") ferns with branches ("stellar nucleus") occurred, but no triangular or doublet forms were observed. Clouds nimbus, low; storm general. Snow flurries continued during a. m. of 19th, with large flakes and the same variety of crystals, the latter more branching and less compact ("fern stellar" type). Temperature, 32°.

March 25—A most peculiar storm: During the forenoon dark heavy clouds gathered as if for a thunder storm. At 11:15 it was dark enough for lights. Snow began to fall and at the same time several claps of thunder were heard. The flakes were large granular pellets, almost like sleet. Later they became less hard, but remained granular. At about 12:30, during the heaviest part of the snow storm, a lightning flash was seen followed by a clap of thunder. The distance of the flash, as judged by the interval between flash and sound, was about one mile. The snow fell until 3:30 p. m. Clouds nimbus and very heavy, especially at the first. Wind from N. W. Temperature about 32° F.

March 29—During the a. m., no snow until 11:30, when heavy fall of snow began. The wind was in N. W., temperature about 32° F. At the first the snow was granular pellets of large size. As the storm progressed the granules became smaller, but showed no crystalline center; toward night, as the temperature fell, the fine granules were intermingled with crystals, and soon the snow consisted altogether of crystals. The crystal types were the solid tabular, small and compact, together with the more branching stellar with solid nucleus ("stellar nucleus").

April 13 and 14—This storm lasted for two days; it set in with rain and turned to damp snow. In the early stages the flakes were masses of wet unshaped snow. As it became colder, granular flakes appeared. Toward night crystalline flakes appeared and were abundant during the evening. These were of the open "fern stellar" type. There were also columnar crystals. The flakes of the second day repeated the first two stages of the first day.

A study of these observations, together with disconnected notes made as opportunity afforded, leads to the following conclusions:

1. The storms generally begin with granular snow in the form of pellets.

2. As the storm progresses granular snow with crystalline centers make their appearance, followed by the open ("fern stellar") type.

3. Next the more solid forms appear and become more numerous, while the open type of crystal generally stops.

4. In the case of light snow, the crystals from high clouds are preponderantly of the solid nucleus type, while those from low clouds are generally of the open structure type. An interesting case of snow from low levels is that of "frost snow," which is always of the open "fern stellar" type.

Observations, of which the foregoing are typical, have led to the formulation of the following hypothesis with respect to the formation of snow crystals. This hypothesis is advanced with the realization that such generalizations are uncertain and subject to revision or rejection. It can only be tested by the comparison of data taken over a wide range of space and time. Mr. Bentley's large body of data was gathered for the purpose rather of securing perfect specimens than to determine the frequency with which each type occurs; nevertheless, it is most valuable from this standpoint also.

The hypothesis is as follows:

I. The primitive crystal is, for the tabular form, the "fern stellar" type, *i. e.* open in structure and with many branches (Fig. 7). For the columnar form it is the hollow column.

II. The solid tabular, solid columnar or granular forms are the final forms of crystal to which all others tend. The doublet is a combination of both.

III. There is a process of transformation from the primitive to the final forms, the process being subject to many varying conditions which generally leave their impress upon the crystal.

IV. There are two general processes: First, a process of accretion in which new material is added to the crystal; second, a process of transformation in which the losses and gains result in a change in form, but not necessarily in amount of material.

In attempting to follow the changes from the open to the closed form many difficulties are met with. The simplest case is that of the granular flake. This is a manifest case of rapid accretion gathering about the central nucleus. If the crystal, during its fall to earth, pass through a stratum of air which is above 32° F., melting will set in, followed, it may be, in a colder stratum by freezing. In this case the drop of water gathers to the center and all trace of the crystal structure is lost. Sometimes, however, the melting is confined to the outlying tips and the parent crystal may be detected beneath a granular coating. For the most part granular snow is of the first kind, but the latter sort is also met with. So far as the writer's observation goes, the nucleus is of the solid tabular type.

If we are to suppose that the solid tabular forms are crystals originally of the open type, it becomes necessary to account for a gradual change from the one to the other. The following extracts from an article entitled "A Contribution to the Theory of Glacial Motion," by Dr. T. C. Chamberlin, would seem to have a bearing on the subject. (*Decennial publication of the University of Chicago, First series, Vol. IX, p. 193*):

"A basal fact ever to be kept in mind is that water in the solid state is always controlled by crystalline forces. When it solidifies from the vapor of the atmosphere, it takes the form of separate crystals. Perfect forms are developed only when the flakes fall quietly through a saturated atmosphere which allows them to grow as they descend. Under other conditions the crystals are imperfect and are mutilated by impact. But, however modified, they are always crystals. The molecules are arranged on the hexagonal plan, and the assemblage is controlled by a strong force, as the expansive power of freezing water shows.

"Snow crystals often continue to grow so long as they are in the atmosphere, but if they pass through an undersaturated stratum of air, or a stratum whose temperature is above 32° F., they suffer from evaporation or melting. When they reach the ground the process of growth and decadence continues, and the crystals grow or diminish according to circumstances. . . .

"The microscopic study of new fallen snow reveals the mode of change from flakes to granules, the slender points and angles of the former yield to melting and evaporation more than the more massive central portions, and this change probably illustrates a law of vital importance. It may often be seen that the water melted from the periphery of a flake gathers about its center, and if the temperature be right, it freezes there.

"In a series of experiments to determine the law of growth, it was found that when the temperature was above the melting point, the growth was appreciably more rapid than when the air was colder, but that there was on the average *an increase under all conditions of temperature.* . . . To follow the process, it should be noted that the surface of the granule is constantly throwing off particles of vapor; that the rate at which the particles are thrown off is dependent among other things on the curvature of the surface, being greater the sharper the curve . . . that other things being equal, the retention of particles also depends on the curvature of the surface, but in the reverse sense, the less curved surface retaining more than the sharply curved one. . . .

"Another factor that enters into the process is that of pressure and tension. The granules are compressed at the points of contact, and put under tension at points not under contact. . . . Tension increases the tendency to evaporation and adds its effect to surface curvature."

Dr. Chamberlin's argument is primarily concerned with the problem of glacial movements, and he applies his reasoning to the granulation of snow in relatively large masses while lying on the ground. It would seem, however, that the same reasoning would apply without essential alteration and with equal force to the individual crystal at any period of its history from its first inception until it finally reaches the ground. The conclusion from such a line of reasoning would be that the center of the crystal would be built up while the outlying parts would be depleted. In this process the most apparent active cause is that of curvature. It is also conceivable that differential pressures might be brought into action by the changes of temperatures the crystal experiences in its downward flight. If so, a pressure would exist at the inner angles and an effective tension at the tips. The process of loss by evaporation and of gain by condensation would be promoted by both of these causes whenever the crystal entered an unsaturated stratum of air. The process would have a maximum rate when melting set in at the tips (but not at the center) and would stop whenever the crystal entered a saturated atmosphere. Upon entering a saturated atmosphere the growth of the crystal would again follow the laws operative at the first formation of the crystal and the additions would be of the "fern stellar" type. (See Fig. 8.) A second period of evaporation and condensation might again set in under favorable circumstances. (See Fig 9.)

Another possible factor in the evaporation-condensation process may perhaps be found in electrical conditions, though such causes should be advanced with great caution. It is permissible to suppose that the particles thrown off by evaporation carry with them an electric charge, leaving the surface from which they come charged in an opposite sense. Since the evaporation would be more active at the tips of the crystal than at the angles, the former region would have a stronger charge than would the latter. In this way a difference of potential would be established between tip and angle, and the molecules of vapor would have a tendency to follow this potential gradient. In other words, there would be a net loss of material to the crystal but there would be a transfer of molecules from the tips to the angles of the crystal, tending to thus produce the solid tabular form. This effect would be operative only at temperatures low enough to render the mass of the crystal a comparative non-conductor, otherwise the potential would be equalized by conduction.

Such a cause might be invoked to explain some of the rarer and more curious forms of crystals, where electric shielding could come into play. This shielding would prevent, or retard, the deposition of material in one part while increasing it in another. (Fig. 10 shows such a possible case.) It is difficult to see how such forms are to be explained unless some cause of this character can be found to be active.

No attempt has been made in this paper to account for the columnar and doublet types. Observation shows that both the hollow and the solid column exist. In some the interior is partly filled, seeming to show that there is a transition from one to the other form. The data relating to these forms are too meager to furnish a basis for generalization.

In closing, it is a pleasure to acknowledge the help of Dr. F. H. Loud during the progress of the observations, and also for valuable suggestions in the preparation of this paper.

PHYSICAL LABORATORY,
COLORADO COLLEGE,
March 9, 1905.

NOTES.

NOTE 1. *Scheekrystalle-Beobachtungen und Studien von Professor G. Hellmann. Berlin, 1893.* Dr. Hellmann, under the heading "Neue Eintheilung der Schneekrystalle," gives the following classification:

"Innerhalb dieser beiden Hauptarten unterscheide ich sodann, wesentlich nach der geometrischen Figur, die sie aufweisen, mehrere Unterarten und gelange so zu folgendem Schema:

I. Tafelförmige Schneekrystalle—d. h. solche mit vorherrschender Flächenentwicklung in der Ebene der Nenbenachsen (N), bei denen also die Länge der Hauptachse (H) sehr ist: H-N gewohnlich kleiner als 0.1.

1. Strahlige Sterne. 2. Plättchen. 3. Kombinationen von beiden.

II. Säulenförmige Schneekrystalle, d. h. solche mit ziemlich gleichmässiger Entwicklung nach den vier Achsen; H÷N gewöhnlich zwischen 1 und 5.

1. Prismen. 2. Pyramiden. 3. Kombinationen von tafel-und säulenförmigen Krystallen."

NOTE 2. Of the various observers, both in Europe and in America, Mr. W. A. Bentley, of Jericho, Vermont, seems to have gathered by far the most extensive mass of data relative to snow crystals. During the past twenty-one years he has each winter secured microphotographs until his collection now comprises over 1,200 negatives. An interesting summary of his work is given in the Annual Summary of the United States Weather Review for 1902.

NOTE 3. G. Tissandier, L'Ocean aérien. Etudes météorologiques. Paris, s. a. p. 129.

NOTE 4. William Scoresby in his two-volume book entitled "An Account of the Arctic Regions," and printed in Edinbourgh in 1820, describes and shows figures of doublets similar to these. These figures are reproduced in *Hellmann's Schneekrystalle,* page 19.

NOTE 5. Dr. Hellmann's little book *Schneekrystalle* contains an interesting historical summary of the subject, including a list of 41 references. The first observer to leave any record seems to have been *Albertus Magnus,* in 1555. Among those who followed him were *Kepler,* in 1611; *Descartes,* 1637; *E. Bartholinus,* in 1660. All of these observers, excepting Kepler, left drawings. Among Descartes' drawings is a very clear one of the doublet. *Robert Hooke,* in 1655, was perhaps the first to apply the microscope to the study of snow forms. His drawings, therefore, show some advance on previous ones.

The most notable contribution is, perhaps, that of *Scrosby,* given in his book on *Arctic Regions,* published in 1820. He gives a large number of drawings and makes a careful analysis of the various forms. The following is an outline of his classification. This account is especially valuable in that it gives observations of snow forms in the Arctic regions:

I. *Lamellar* crystals. (a) *Stellarform,*—varies in size from the smallest speck to about one-third of an inch in diameter. It occurs in greatest profusion when the temperature approaches the freezing point.

(b) *Regular hexagon.* Occurs in moderate as well as in the lowest temperatures; but diminishes in size as the cold increases. Size varies from the smallest visible speck to about one-tenth inch diameter.

(c) Aggregations of hexagons, with radii or spines, and projecting angles.

II. *A lamellar or spherical* nucleus with spinous ramifications in different planes.

(a) The fundamental figure, consisting of a lamellar crystal from the lateral and terminal planes of which arise small spines. These spines arise either from one or both of the lateral and terminal planes; and always maintain the usual angle of 60 degrees with the plane from which they take their rise. The diameter sometimes exceeds the fourth of an inch. It falls most frequently at a temperature of 20 or 25 degrees.

III. *Fine spiculae* or six-sided prisms. These are sometimes very delicate and crystalline; at others, white and rough. The finest specimens, resembling bits of white hair not over one-fourth of an inch in length, are small and clear. The larger ones exhibit a fibrous or prismatic structure. Some of these are one-third of an inch in length. This genus is only seen when the temperature is near the freezing point. When the thermometer is at 28 degrees the finer specimens occur; when about freezing, the coarser appear. The latter are very common during fog showers, and appear to be composed of the frozen particles of the fog, and to have their origin in the lower parts of the atmosphere.

IV. *Hexagonal pyramids.* A rare variety, consisting apparently of a triangular pyramid, the base may also be of six sides. The height is about one-thirtieth of an inch.

V. *Spiculae or prisms having one or both extremities inserted in the center of a lamellar crystal.* Cases are noted of one, two and three tabular crystals. The length is from one-thirtieth to one-sixth of an inch. The temperature on two occasions was 22 and 20 degrees.

The first to apply photography to this study seems to have been Mr. Bentley, in 1885. Dr. Neuhauss in 1892 uses this method, and Dr. Hellmann's book is illustrated with Dr. Neuhauss' photographs.

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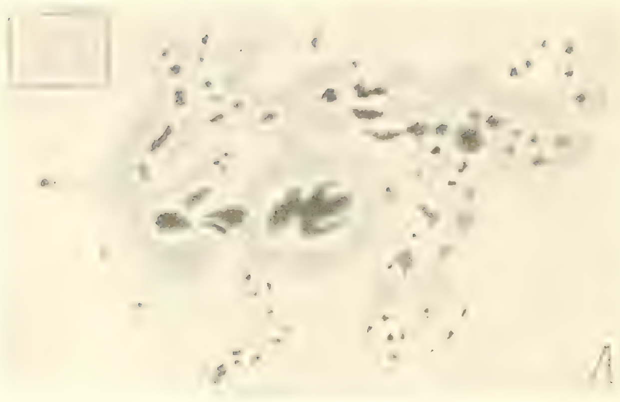
SCIENCE SERIES.

(Continued on inside of back cover.)

INTRODUCTORY NOTE.

Of the two Observatory Bulletins allotted to the current college year, the present number contains some essays connected with the observatory's astronomical work. The second, appearing in the spring of 1906, is designed to contain the meteorological statistics for 1905 and related papers continuing the plan exemplified in the publication of last April.



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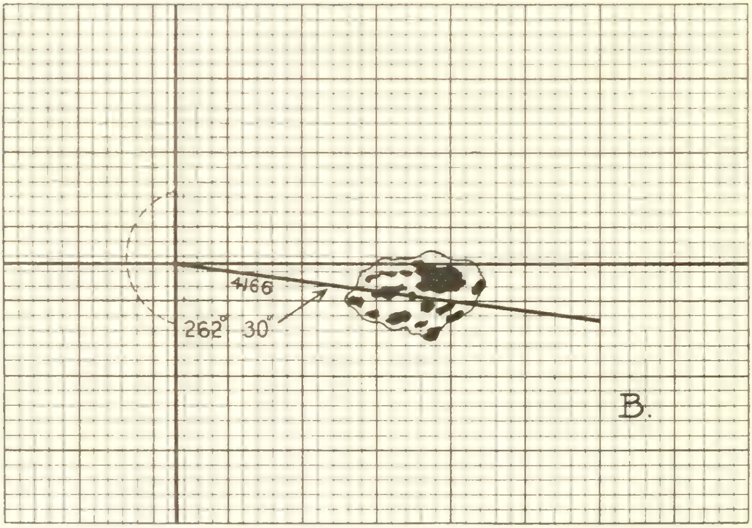


A. The great sun-spot, from a drawing made at the Royal Observatory at Belgium. (The circle represents the comparative size of the earth.)

B. A drawing of the same spot, Colorado Springs, February 1, 11.50 A.M.

ON EULER'S SUMMATION OF SERIES OF RECIPROCAL POWERS AND RELATED SERIES, GIVING SOME RECURRENCE FORMULAE FOR THE CONSTANTS INVOLVED.*

By W. Noël Birchby.

1. *Introductory.*— The series

$$1 + \frac{1}{2^{2m}} + \frac{1}{3^{2m}} + \cdots \text{ ad } \infty,$$

and

$$1 + \frac{1}{3^{2m}} + \frac{1}{5^{2m}} + \cdots \text{ ad } \infty,$$

were summed about the year 1740 by Leonhard Euler and John Bernoulli independently, in terms of Bernoulli's Numbers.† In 1748 Euler found the sums of these and several related series without the use of Bernoulli's Numbers,‡ by a simple and direct method which, however, involved assumptions regarding the products of semi-convergent series, that needed further investigation. The means have not been at hand until a comparatively recent date, for removing these difficulties, and in the meantime most of Euler's results have been verified by other methods. The object of the present paper is to give Euler's proof a more rigorous foundation, and incidentally to develop some recurrence formulae connecting the coefficients of π^{2m} in the identity

$$k_{2m}\pi^{2m} \equiv 1 + \frac{1}{2^{2m}} + \frac{1}{3^{2m}} + \cdots, \ (m = 1, 2, 3 \cdots),$$

* A thesis submitted June 6, 1905 for the degree of Master of Arts, Colorado College.

† L. Euler: *Comm. Ac. Petrop.*, 1740 and Bernoulli; *Op.*, t. IV, p. 10.

‡ L. Euler: *Introd. in Anal. Inf.*, Lib. I, Cap. X.

and several similar cases. In one case we shall also prove some interesting properties of the coefficients. The modern summations of these series have been effected in terms of Bernoulli's and Euler's Numbers, two sets of constants closely related to our coefficients, as will presently appear.

2. *Notation.*—The following notation will be used ;

$$1 + \frac{1}{2^{2m}} + \frac{1}{3^{2m}} + \cdots \equiv \sum_{1}^{\infty}{}' \frac{1}{r^{2m}} \equiv \sigma_{2m} \equiv k_{2m}\pi^{2m} ; \qquad (1)$$

$$1 + \left(\frac{-1}{3}\right)^{m} + \left(\frac{+1}{5}\right)^{m} + \left(\frac{-1}{7}\right)^{m} + \cdots \equiv \sum_{1}^{\infty}{}' \frac{(-1)^{m(r-1)}}{(2r-1)^{m}} \qquad (2)$$

$$\equiv \sigma_m' \equiv k_m'\pi^m.$$

$$\left(\frac{1}{1-a}\right)^{m} + \left(\frac{-1}{1+a}\right)^{m} + \left(\frac{1}{3-a}\right)^{m} + \left(\frac{-1}{3+a}\right)^{m}$$

$$+ \cdots \left[\begin{array}{l} a \neq \pm K, \\ K = 1, 3, 5, \cdots \end{array}\right] \equiv \sigma_m''' \equiv k_m'''\pi^m. \qquad (3)$$

B_m and E_m will be used to represent the mth of Bernoulli's and Euler's Numbers respectively. The following summations in terms of these constants are known :*

$$\sigma_{2m} \equiv k_{2m}\pi^{2m} = \frac{2^{2m-1}B_m}{(2m)!}\pi^{2m}. \qquad (4)$$

$$\sigma_{2m}' \equiv k_{2m}'\pi^{2m} = \frac{(2^{2m}-1)B_m}{2(2m)!}\pi^{2m}. \qquad (5)$$

$$\sigma_{2m+1}' \equiv k_{2m+1}'\pi^{2m+1} = \frac{E_m}{2^{2m+2}(2m)!}\pi^{2m+1}. \qquad (6)$$

It will be noticed that these relations give a simple connection between the coefficients k_{2m}, k_{2m}', k_{2m+1}' and the corresponding Bernoulli or Euler Number.

3. *Outline of Euler's Method.*—Euler's method, in brief, was to take two independent expressions for the same trigonometrical function of θ, one being an infinite power-series in θ, the other an infinite product ; to expand the latter in powers of θ by ordinary multiplication, and then to equate the coeffi-

*CHRYSTAL : *Alg.*, Vol. II, Ch. XXX, § 14.

cients of like powers of θ in the two series. For instance, suppose,

$$F(\theta) = a_0 + a_1\theta + a_2\theta^2 + \cdots, \tag{7}$$

and also

$$F(\theta) = (1 + \alpha_1\theta)(1 + \alpha_2\theta)(1 + \alpha_3\theta)\cdots, \tag{8}$$

or, on multiplying (8) out,

$$F(\theta) = 1 + \sum\alpha_i \cdot \theta + \sum\alpha_i\alpha_k \cdot \theta^2 + \sum\alpha_i\alpha_k\alpha_l \cdot \theta^3 + \cdots, \tag{9}$$

where $\sum\alpha_i\alpha_k$ is an abbreviation meaning that all possible products of two of the quantities $\alpha_1, \alpha_2, \alpha_3, \cdots$, are to be formed and their sum taken; similarly for $\sum\alpha_i\alpha_k\alpha_l$, etc. Then comparing coefficients in (7) and (9) we have;

$$a_0 = 1\,;\ a_1 = \sum\alpha_i\,;\ a_2 = \sum\alpha_i\alpha_k\,;\ \text{etc.}$$

Since the series $\alpha_1, \alpha_2, \alpha_3, \cdots$, is infinite, $\sum\alpha_i\alpha_k$ represents the doubly infinite series,

$$\begin{aligned} &\alpha_1\alpha_2 + \alpha_1\alpha_3 + \alpha_1\alpha_4 + \cdots, \\ &+ \alpha_2\alpha_3 + \alpha_2\alpha_4 + \alpha_2\alpha_5 + \cdots, \\ &+ \alpha_3\alpha_4 + \alpha_3\alpha_5 + \alpha_3\alpha_6 + \cdots, \\ &\cdot\quad \cdot\quad \cdot\quad \cdot\quad \cdot\quad \cdot\quad \cdot\quad \cdot \end{aligned}$$

$\sum\alpha_i\alpha_k\alpha_l$ stands for a triply infinite series, and so on. To insure the validity of this process the following points should be proven: (1) That the power-series and the infinite product are convergent for some range of values of θ; (2) that the coefficients in the expansion of the infinite product, being in general multiple infinite series, are convergent; (3) that the expansion of the infinite product is a convergent series for some range of θ included in the range of convergency of the power-series.

4. *Auxiliary Theorem.* — Before applying Euler's method we will prove a preliminary theorem. If $\alpha_1, \alpha_2, \alpha_3, \cdots \alpha_n$, are any n quantities; $s_1, s_2, s_3, \cdots$, the sums of their first, second, third, $\cdots$, powers, respectively; $p_1, p_2, p_3, \cdots$, the sums of all the possible products formed by taking them one, two, three, $\cdots$, at a time, respectively, we have from the Theory of Equations (Newton's formula),*

* CAJORI: *Theory of Equations,* Chap. VII, § 68.

$$s_m - p_1 s_{m-1} + p_2 s_{m-2} - \cdots + (-1)^{m-1} p_{m-1} s_1 + (-1)^m m p_m = 0 \quad (10)$$

so long as $m \ngtr n$. This relation is independent of n and therefore will remain true if we allow n to increase without limit, provided that, in that case, the expressions involved are convergent. The quantity s_r becomes the infinite series

$$a_1{}^r + a_2{}^r + a_3{}^r + \cdots,$$

while p_r is a multiply infinite series. We need only examine products of s_1, s_2, s_3, $\cdots$, and their powers, since we have,*

$$p_r = \frac{1}{r\,!}\begin{vmatrix} s_1 & 1 & 0 & 0 & \cdots & 0 \\ s_2 & s_1 & 2 & 0 & \cdots & 0 \\ s_3 & s_2 & s_1 & 3 & \cdots & 0 \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ s_r & s_{r-1} & s_{r-2} & s_{r-3} & \cdots & s_1 \end{vmatrix} \quad (11)$$

a formula by which we may obtain p_1, p_2, p_3, $\cdots$, in terms of such products.

If, now, we put

$$a_1 = 1,\ a_2 = -\tfrac{1}{3},\ a_3 = \tfrac{1}{5},\ \cdots\ a_r = (-1)^{r-1} 1/(2r-1),\ \cdots,$$

the number of a's being infinite, we get,

$$s_1 = \sigma_1' \equiv 1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \cdots \text{ ad } \infty,$$

$$s_2 = \sigma_2' \equiv 1 + \frac{1}{3^2} + \frac{1}{5^2} + \frac{1}{7^2} + \cdots \text{ ad } \infty,$$

and in general

$$s_m = \sigma_m' \equiv \sum_{r=1}^{\infty} \frac{(-1)^{m(r-1)}}{(2r-1)^m}.$$

All these series are convergent, and all are absolutely convergent except the first. The product of two absolutely convergent series, formed according to Cauchy's rule, is absolutely convergent.† Also the product of an absolutely convergent

*CAJORI: *Theory of Equations*, Chap. VII, § 69.

†CHRYSTAL; *Alg.*, 1889, Vol. II, Ch. XXVI, § 34, Cor., p. 154.

series and a semi-convergent series is convergent.* The only doubt that arises is in regard to the powers of σ_1', since this is a semi-convergent series, and the above mentioned theorems would not apply. A proof has been given of the convergency of the powers of certain semi-convergent series, of which ours is a particular case, showing that any power of this series is convergent.† We give, at the end of this paper, an elementary proof that the square of σ_1' is convergent. From these considerations it follows that all the products in the determinant (11) when $\sigma_1', \sigma_2', \cdots, \sigma_r'$ are put in place of $s_1, s_2, \cdots, s_r$, are convergent multiple series, and if we represent by P_r what p_r becomes for these values of $s_1, s_2, \cdots, s_r$, that P_r is a convergent expression for all finite values of r.

5. *Euler's Problem.*—We are now ready to take up Euler's problem, using as the two expressions to be compared,

$$\sin\theta + \cos\theta = \left(1 + \frac{4\theta}{\pi}\right)\left(1 - \frac{4\theta}{3\pi}\right)\left(1 + \frac{4\theta}{5\pi}\right)\cdots, \quad (12)$$

and

$$\sin\theta + \cos\theta = 1 + \theta - \frac{\theta^2}{2\,!} - \frac{\theta^3}{3\,!} + \frac{\theta^4}{4\,!} + \frac{\theta^5}{5\,!} - \cdots. \quad (13)$$

The right hand members of these equations are both convergent for all values of θ. The product in (12) may be obtained from the absolutely convergent product,‡

$$\cos\theta + \sin\theta\cot\varphi = \left(1 + \frac{\theta}{\varphi}\right)\prod_{n=1}^{\infty}\left\{1 - \frac{2\varphi\theta + \theta^2}{n^2\pi^2 - \varphi^2}\right\}, \quad (14)$$

by placing $\varphi = \pi/4$, and decomposing each factor after the first into two. By adding the series

$$\sin\theta = \theta - \frac{\theta^3}{3\,!} + \frac{\theta^5}{5\,!} - \cdots,$$

and

$$\cos\theta = 1 - \frac{\theta^2}{2\,!} + \frac{\theta^4}{4\,!} - \cdots,$$

and arranging the result according to the powers of θ, which

* CHRYSTAL ; *Alg.*, Vol. II, Ch. XXVI, § 14, p. 127.

† CAJORI ; *Am. Jour. Math.*, Vol. XVIII, 1896, p. 204.

‡ CHRYSTAL ; *Alg.*, Vol. II, Chap. XXX, § 8, p. 329.

is allowable, since the two series are absolutely convergent, we obtain (13).

As (12) is convergent for all values of θ we may expand it in powers of θ, and we get,

$$\sin\theta + \cos\theta = 1 + \frac{4\theta}{\pi}P_1 + \frac{4^2\theta^2}{\pi^2}P_2 + \frac{4^3\theta^3}{\pi^3}P_3 + \cdots, \quad (15)$$

where $P_1, P_2, \cdots P_r$ have the meaning assigned above. In order to determine the convergence of (15) we notice that since $P_1, P_2, \cdots P_r$ are all finite,* (15) is less than $P_m(1 + 4\theta/\pi + 4^2\theta^2/\pi^2 + \cdots)$ if P_m is the greatest of the quantities P_r, and therefore converges if $|\theta| < \pi/4$. Since it converges for this range of values of θ and is an expansion in powers of θ of the same function as (13), which is absolutely convergent for all values of θ, (15) is absolutely convergent for all values of θ. It follows that the coefficients of like powers of θ in (13) and (15) are equal, and we get

$$P_1 = \frac{\pi}{4}; \; P_2 = -\frac{\pi^2}{4^2 2!}; \; P_3 = \frac{\pi^3}{4^3 3!}; \; \cdots P_r = \frac{(-1)^{r-1}\pi^r}{4^r r!}; \cdots. \quad (16)$$

Now putting,

$$\left.\begin{aligned} k_1'\pi &= \sigma_1' \equiv 1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \cdots \\ k_2'\pi^2 &= \sigma_2' \equiv 1 + \frac{1}{3^2} + \frac{1}{5^2} + \frac{1}{7^2} + \cdots \\ &\cdots\cdots\cdots\cdots \\ k_m'\pi^m &= \sigma_m' \equiv \sum_{r=1}^{\infty} \frac{(-1)^{m(r-1)}}{(2r-1)^m} \\ &\cdots\cdots\cdots\cdots \end{aligned}\right| \quad (17)$$

* It may be shown that P_r is numerically less than unity for all values of r, by means of the formula

$$(-1)^{r+1}(r)_n = \frac{1}{2r-1}(r-1)_{r-1} - \frac{1}{2r+1}(r-1)_r + \frac{1}{2r+3}(r-1)_{r+1} - \cdots + (-1)^{n-r}\frac{1}{2n-1}(r-1)_{n-1},$$

in which the notation $(p)_q$ stands for the sum of all possible products of p different factors taken from the q quantities

$$1, -\tfrac{1}{3}, +\tfrac{1}{5}, \cdots \frac{(-1)^{q+1}}{2q-1}.$$

and substituting these values of $P_1, P_2, \cdots, P_2, \cdots$, and $\sigma_1', \sigma_2', \cdots, \sigma_r', \cdots$, for $p_1, p_2, \cdots, p_r, \cdots$ and $s_1, s_2, \cdots, s_r, \cdots$, in Newton's formula (10) we have, after dividing through by π^n,

$$k_m' - \frac{k_{m-1}'}{4} - \frac{k_{m-2}'}{4^2 2\,!} + \frac{k_{m-3}'}{4^3 3\,!} + \frac{k_{m-4}'}{4^4 4\,!} - \cdots$$

$$+\begin{cases} (-1)^{\frac{m-1}{2}} \dfrac{k_1'}{4^{m-1}(m-1)\,!} + (-1)^{\frac{m+1}{2}} \dfrac{m}{4^m m\,!} = 0 \ (m \text{ odd}), \\ (-1)^{\frac{m}{2}} \dfrac{k_1'}{4^{m-1}(m-1)\,!} + (-1)^{\frac{m}{2}} \dfrac{m}{4^m m\,!} = 0 \ (m \text{ even}). \end{cases} \qquad (A)$$

This formula enables us to calculate the constants k_r' in succession, by putting $1, 2, 3, \cdots, r, \cdots$ successively for m. From the form of (A) we see that all the k's are rational quantities. The infinite product (12) may be obtained from the following formula, given by Euler,* as may also the infinite product in (23) of this paper;

$$\cos z + \tan \tfrac{1}{2}g \sin z$$

$$= \left(1 + \frac{2z}{\pi - g}\right)\left(1 - \frac{2z}{\pi + g}\right)\left(1 + \frac{2z}{3\pi - g}\right)\left(1 - \frac{2z}{3\pi + g}\right)\cdots. \qquad (18)$$

The other infinite products used in this discussion were also found by him. Euler's demonstrations are not altogether satisfactory according to modern standards, but rigorous proofs of all these formulæ have been given.†

By pursuing the same method with the identities

$$\sin \theta = \theta - \frac{\theta^3}{3\,!} + \frac{\theta^5}{5\,!} - \frac{\theta^7}{7\,!} + \cdots, \qquad (19)$$

and

$$\sin \theta = \theta \left(1 - \frac{\theta^2}{\pi^2}\right)\left(1 - \frac{\theta^2}{2^2\pi^2}\right)\left(1 - \frac{\theta^2}{3^2\pi^2}\right)\cdots, \qquad (20)$$

and placing

$$k_{2m}\pi^{2m} = \sigma_{2m} \equiv 1 + \frac{1}{2^{2m}} + \frac{1}{3^{2m}} + \cdots, \qquad (21)$$

we obtain the formula

* *Int. in Anal. Inf.*, Chap. IX, § 164.

† CHRYSTAL, *Alg.*, Vol. II, Chap. XXX.

$$k_{2m} - \frac{k_{2m-2}}{3\,!} + \frac{k_{2m-4}}{5\,!} - \cdots + (-1)^{m-1}\frac{k_2}{(2m-1)\,!} + (-1)^m \frac{m}{(2m+1)\,!} = 0. \qquad (B)$$

Also, from

$$\cos\theta = 1 - \frac{\theta^2}{2\,!} + \frac{\theta^4}{4\,!} - \frac{\theta^6}{6\,!} + \cdots, \qquad (22)$$

and

$$\cos\theta = \left(1 - \frac{4\theta^2}{\pi^2}\right)\left(1 - \frac{4\theta^2}{3^2\pi^2}\right)\left(1 - \frac{4\theta^2}{5^2\pi^2}\right)\cdots, \qquad (23)$$

putting

$$k_{2m}'\pi^{2m} = \sigma'_{2m} \equiv 1 + \frac{1}{3^{2m}} + \frac{1}{5^{2m}} + \cdots, \qquad (24)$$

where the constants are the same as the even ones in (17), we obtain the recurrence formula,

$$k_{2m}' - \frac{k_{2m-2}'}{4^2\,!} + \frac{k_{2m-4}'}{4^2 4\,!} - \cdots + (-1)^{m-1}\frac{k_2'}{4^{m-1}(2m-2)\,!} + (-1)^m \frac{m}{4^m(2m)\,!} = 0. \qquad (C)$$

This formula gives a relation between the even constants of (A). In the derivation of (B) and (C) no difficulty arises in regard to the convergence of the expressions involved, as all the factor-series are absolutely convergent.

If we use the most general formulæ

$$\cos\left(\frac{\pi}{2}v\right) + \tan\left(\frac{\pi}{2}a\right)\sin\left(\frac{\pi}{2}v\right)$$

$$= \left(1 + \frac{v}{1-a}\right)\left(1 - \frac{v}{1+a}\right)\left(1 + \frac{v}{3-a}\right)\left(1 - \frac{v}{3+a}\right)\cdots \qquad (25)$$

$$= \left[1 - \frac{\pi^2 v^2}{2^2 2\,!} + \frac{\pi^4 v^4}{2^4 4\,!} - \cdots\right]$$

$$+ \tan\left(\frac{\pi}{2}a\right)\left[\frac{\pi}{2}v - \frac{\pi^3 v^3}{2^3 3\,!} + \frac{\pi^5 v^5}{2^5 5\,!} - \cdots\right].*$$

* Given in a slightly different form by Euler, *Int. in Anal. Inf.*, Lib. I, Cap. IX, § 164, end.

and place

$$k_m'''\pi^m = \sigma_m''' \equiv \left(\frac{1}{1-a}\right)^m + \left(\frac{-1}{1+a}\right)^m + \left(\frac{1}{3-a}\right)^m + \left(\frac{-1}{3+a}\right)^m + \cdots, \tag{26}$$

we get, by the same method,

$$k_m''' - \frac{k_{m-1}'''r}{2} - \frac{k_{m-2}'''}{2^2 2\,!} + \frac{k_{m-3}'''r}{2^3 3\,!} + \frac{k_{m-4}'''}{2^4 4\,!} - \cdots$$

$$+\begin{cases} (-1)^{\frac{m-1}{2}} \dfrac{k_1'''}{2^{m-1}(m-1)!} + (-1)^{\frac{m+1}{2}} \dfrac{mr}{2^m m\,!} = 0 & (m \text{ odd}) \\ (-1)^{\frac{m}{2}} \dfrac{k_1'''r}{2^{m-1}(m-1)\,!} + (-1)^{\frac{m}{2}} \dfrac{m}{2^m m\,!} = 0 & (m \text{ even}) \end{cases} \tag{D}$$

where $r = \tan(\pi a/2)$.

In order to establish (D) it is necessary to test the convergence of the series σ_m''' and its powers and products. In the first place we notice that if a in (26) is any odd integer, positive or negative, the series σ_m''' has one infinite term and therefore becomes divergent. It will be necessary then to exclude these values of a, and we will suppose in what follows that

$$a \neq \pm(2p-1), \qquad (p = 0, 1, 2, 3, \cdots) \tag{27}$$

With this restriction the series σ_m''' is absolutely convergent for every positive integral value of m except 1; for each term of both series

$$T_m = \frac{1}{(1-a)^m} + \frac{1}{(3-a)^m} + \frac{1}{(5-a)^m} + \cdots$$

$$U_m = \frac{1}{(1+a)^m} + \frac{1}{(3+a)^m} + \frac{1}{(5+a)^m} + \cdots$$

under these restrictions has a finite ratio to the corresponding term of the absolutely convergent series

$$\sum_{p=1}^{\infty} \frac{1}{(2p-1)^m} \qquad (m > 1),$$

and the limits of these ratios are in each case unity. Therefore the series formed by adding T_m and U_m, placing the terms in any order, is absolutely convergent. The series

$$\sigma_1''' = \frac{1}{1-a} - \frac{1}{1+a} + \frac{1}{3-a} - \frac{1}{3+a} + \cdots$$

is not absolutely convergent, but under restriction (27), the ratio of its nth term to the nth term of

$$\sum_1^{\prime} \frac{(-1)^{n-1}}{n}$$

is finite for all values of n and the limit of the ratio is unity. Therefore the powers of σ_1''' are all convergent, since we know that all the powers of

$$\sum_1^{\prime} \frac{(-1)^{n-1}}{n}$$

are so.* Formula (D) includes (A) and (C) as special cases, for if we put $a = \frac{1}{2}$, and therefore $r = \tan(\pi a/2) = 1$, we get $\sigma_m''' = 2^m \sigma_m'$ and therefore, for this value of r, $k_m''' = 2^m k_m'$. Substituting these values of k_m''' and σ_m''' in (D) and dividing by 2^m, it reduces to (A). Similarly, by making $r = a = 0$, we may reduce (D), for m even, to (C).

6. *Independent Values of Constants in Determinant Form.* — From the recurrence formulæ (A), (B), (C), and (D) we can easily obtain a value for the mth constant in the form of a determinant. For instance, by putting m successively equal to $1, 2, 3, \cdots m$, in (B) we obtain,

$$k_2 - \frac{1}{3\,!} = 0,$$

$$k_4 - \frac{k_2}{3\,!} + \frac{2}{5\,!} = 0,$$

. . . .

$$k_{2m} - \frac{k_{2m-2}}{3\,!} + \cdots + (-1)^m \frac{m}{(2m+1)\,!} = 0,$$

a system of m equations in the m unknowns, $k_2, k_4, \cdots k_{2m}$.

* CAJORI : *Am. Journ. Math.*, 1896, Vol. XVIII, p. 201.

Solving for k_{2m} we obtain after a few simple reductions,

$$k_{2m} = \begin{vmatrix} \frac{1}{3!} & 1 & 0 & \cdots & 0 \\ \frac{2}{5!} & \frac{1}{3!} & 1 & \cdots & 0 \\ \frac{3}{7!} & \frac{1}{5!} & \frac{1}{3!} & \cdots & 0 \\ \vdots & \vdots & \vdots & & \vdots \\ \frac{m}{(2m+1)!} & \frac{1}{(2m-1)!} & \frac{1}{(2m-3)!} & \cdots & \frac{1}{3!} \end{vmatrix}.$$

Treating (A), (C) and (D), respectively, in a similar manner, we get, after some reductions:

$$k_m' = \frac{1}{4^m} \begin{vmatrix} 1 & -1 & 0 & 0 & \cdots & 0 \\ \frac{2}{2!} & 1 & 1 & 0 & \cdots & 0 \\ \frac{3}{3!} & \frac{-1}{2!} & 1 & -1 & \cdots & 0 \\ \frac{4}{4!} & \frac{1}{3!} & \frac{1}{2!} & 1 & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots & & \vdots \\ \frac{m}{m!} & \frac{(-1)^m}{(m-1)!} & \frac{1}{(m-2)!} & \frac{(-1)^m}{(m-3)!} & \cdots & 1 \end{vmatrix},$$

$$k_{2m}' = \frac{1}{4^m} \begin{vmatrix} \frac{1}{2!} & 1 & 0 & \cdots & 0 \\ \frac{2}{4!} & \frac{1}{2!} & 1 & \cdots & 0 \\ \frac{3}{6!} & \frac{1}{4!} & \frac{1}{2!} & \cdots & 0 \\ \vdots & \vdots & \vdots & & \vdots \\ \frac{m}{(2m)!} & \frac{1}{(2m-2)!} & \frac{1}{(2m-4)!} & \cdots & \frac{1}{2!} \end{vmatrix},$$

$$k_m''' = \frac{r^{1-p}}{2^m} \begin{vmatrix} 1 & -1 & 0 & 0 & \cdots & 0 \\ \frac{2}{2!} & r^2 & 1 & 0 & \cdots & 0 \\ \frac{3}{3!} & \frac{-1}{2!} & 1 & -1 & \cdots & 0 \\ \frac{4}{4!} & \frac{r^2}{3!} & \frac{1}{2!} & r^2 & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots & & \vdots \\ \frac{m}{m!} & \frac{(-1)^m r^{2p}}{(m-1)!} & \frac{1}{(m-2)!} & \frac{(-1)^m r^{2p}}{(m-3)!} & \cdots & r^{2p} \end{vmatrix} .$$

$$\begin{bmatrix} m \text{ even}, p = 1 \\ m \text{ odd}, p = 0 \end{bmatrix}$$

7. *Properties of the constants in* (D).—From the form of (D) we may deduce some interesting properties of k_m''' in regard to r. By putting m successively equal to 1, 2, 3, we find,

$$k_1''' = \frac{r}{2}\,; \quad k_2''' = \tfrac{1}{4}(r^2 + 1)\,; \quad k_3''' = \frac{r}{8}(r^2 + 1). \tag{29}$$

We will first show that, when m is odd, k_m''' has r as a factor. If we take m odd, and assume that k_1''', k_3''', k_5''', $\cdots$, k_{m-2}''', all have the factor r, we may put

$$k_{m-2}''' = rb_{m-2}\,; \quad k_{m-4}''' = rb_{m-4}\,; \quad \cdots\,; \quad k_1''' = rb\,; \tag{30}$$

where b_{m-2}, b_{m-4}, $\cdots$, b_1, are rational integral functions of r. Substituting the values of (24) in (D), and transposing all terms except the first, it becomes

$$k_m''' = \frac{k_{m-1}''' r}{2} + \frac{b_{m-2} r}{2^2 2!} - \cdots + (-1)^{\frac{m-1}{2}} \frac{b_1 r}{2^{m-1}(m-1)!} + (-1)^{\frac{m-1}{2}} \frac{mr}{2^m m!}. \tag{31}$$

which shows that r is a factor of k_m''' if it is a factor of all the preceding odd k's. Therefore, since $k_1''' = r/2$, all odd k's contain the factor r.

Secondly, all even k's are functions of r^2, and all odd k's are of the form $r\varphi(r^2)$, for if this is true up to k_m''', m being odd we may put

$$k_{m-1}''' = f_{m-1}(r^2);\ k_{m-2}''' = rf_{m-2}(r^2);\ \cdots k_1''' = rf_1(r^2), \quad (32)$$

by which (D) becomes,

$$k_m''' = \frac{rf_{m-1}(r^2)}{2} + \frac{rf_{m-2}(r^2)}{2^2 2\,!} - \cdots + (-1)^{\frac{m-1}{2}} \frac{rf_1(r^2)}{2^{m-1}(m-1)\,!} + (-1)^{\frac{m+1}{2}} \frac{rm}{2^m m\,!} \equiv rf_m(r^2), \quad (33)$$

therefore,

$$k_{m+1}''' = \frac{r^2 f_m(r^2)}{2} + \frac{f_{m-1}(r^2)}{2^2 2\,!} - \cdots + (-1)^{\frac{m+1}{2}} \frac{r^2 f_1(r^2)}{2^m m\,!} + (-1)^{\frac{m+1}{2}} \frac{m+1}{2^{m+1}(m+1)\,!} \equiv f_{m+1}(r^2), \quad (34)$$

From (33) and (34), since by (29) $k_1'''=r/2$ and $k_2'''=\frac{1}{4}(r^2+1)$, the theorem follows by induction. From this theorem we deduce the fact that if r is the square root of a rational quantity, k_m''' is rational when m is even, and is a rational quantity multiplied by r, when m is odd. Thus if we put $r = \tan(\pi a/2) = \sqrt{3}$, and therefore $a = \frac{2}{3}$, we get

$$k_1''' = \tfrac{1}{2}\sqrt{3}\,;\ k_2''' = 1\,;\ k_3''' = \tfrac{1}{2}\sqrt{3}\,;\ k_4''' = \tfrac{5}{6}\,;\ k_5''' = \tfrac{11}{24}\sqrt{3}\,;\ \text{etc.}$$

These values of r, a, and k_m''' will, if placed in (26), produce several examples given by Euler.*

Lastly we may show that all the k's after k_1''' contain the factor (r^2+1). For if this is true up to k_m''' we may put

$$k_{m-1}''' = (r^2+1)b_{m-1}'\,;\ k_{m-2}''' = (r^2+1)b_{m-2}'\,;\ \cdots,\ k_2''' = (r^2+1)b_2'\,; \quad (35)$$

where b_{m-1}', b_{m-2}', $\cdots$, b_2', are rational integral functions of r. Substituting these values in (D), and remembering that $k_1''' = r/2$, we get

$$k_m''' = \frac{r(r^2+1)b_{m-1}'}{2} + \frac{(r^2+1)b_{m-2}'}{2^2\,2\,!} - \frac{r(r^2+1)b_{m-3}'}{2^3\,3\,!} - \cdots$$

* *Int. in Anal. Inf.*, Lib. I, Chap. X, § 177.

$$+\begin{cases}(-1)^{\frac{m-1}{2}}\left[\dfrac{r}{2^{m-1}(m-1)!}-\dfrac{r}{2^{m-1}(m-1)!}\right] & (m \text{ odd}),\\ (-1)^{\frac{m}{2}}\dfrac{r^2+1}{2^m(m-1)!} & (m \text{ even}),\end{cases} \tag{36}$$

which shows that whether m be odd or even, k_m''' contains the factor (r^2+1). Since by (29) $k_2'''=\frac{1}{4}(r^2+1)$ the theorem follows. These properties may easily be proven by means of the determinant value of k_m'''.

8. *Relations to known Recurrence Formulæ.*—If B_m, E_m, and β_m be defined by the following identities, where B_m and E_m stand for the mth of Bernoulli's and Euler's numbers, respectively;

$$x\cot x = 1 - 2^2B_1\frac{x^2}{2!} - 2^4B_2\frac{x^4}{4!} - 2^6B_3\frac{x^6}{6!} - \cdots, \tag{37}$$

$$\sec x = 1 + E_1\frac{x^2}{2!} + E_2\frac{x^4}{4!} + E_3\frac{x^6}{6!} + \cdots, \tag{38}$$

$$\tan x = \beta_1 x + \beta_2\frac{x^3}{3!} + \beta_3\frac{x^5}{5!} + \cdots, \tag{39}$$

the following relations are known to exist: *

$$\beta_m = \frac{2^{2m}(2^{2m}-1)}{2m}B_m$$

$$\left.\begin{aligned}\sigma_{2m}' &= \left(\frac{\pi}{2}\right)^{2m}\frac{\beta_m}{2(2m-1)!} = \left(\frac{\pi}{2}\right)^{2m}\frac{2^{2m-1}(2^{2m}-1)}{(2m)!}B_m\\ \sigma_{2m+1}' &= \left(\frac{\pi}{2}\right)^{2m+1}\frac{E_m}{2(2m)!};\quad \sigma_{2m} = \frac{2^{2m-1}\pi^{2m}}{(2m)!}B_m\end{aligned}\right\} \tag{40}$$

where σ_{2m}', σ_{2m+1}', σ_{2m} are defined by (17) and (21).† Since $\sigma_m' = k_m'\pi^m$ and $\sigma_{2m} = k_{2m}\pi^{2m}$, we get the relations

$$\left.\begin{aligned}k_{2m}' &= \frac{\beta_m}{2^{2m-1}(2m-1)!} = \frac{(2^{2m}-1)}{2(2m)!}B_m,\\ k_{2m+1}' &= \frac{E_m}{2^{2m-2}(2m)!},\quad k_{2m} = \frac{2^{2m-1}B_m}{(2m)!}\end{aligned}\right\} \tag{41}$$

* SAALSCHÜTZ: *Vorlesungen über die Bernoullischen Zahlen*, Berlin, 1893, Abschnitt 1, § 4, p. 22.

† CHRYSTAL: *Alg.* Vol. II, Chap. XXX, § 15, p. 342.

These relations show that the constants k_m' and k_{2m} are closely related to Bernoulli's and Euler's numbers. If we substitute these values in (A), (B) and (C), they reduce to the following known recurrence formulæ between B_m, E_m, and β_m.

When m is odd (A) reduces to

$$E_m - \binom{2m}{1}\frac{\beta_m}{2} - \binom{2m}{2}\frac{E_{m-1}}{2^2} + \binom{2m}{3}\frac{\beta_{m-1}}{2^3} + \cdots + (-1)^m\binom{2m}{2m-1}\frac{\beta_1}{2^{2m-1}} + (-1)^m\binom{2m}{2m}\frac{E_0}{2^{2m}} + \frac{(-1)^{m+1}}{2^{2m}} = 0. \qquad (A')$$

When m is even (A) reduces to

$$\beta_m - \binom{2m-1}{1}\frac{E_{m-1}}{2} - \binom{2m-1}{2}\frac{\beta_{m-1}}{2^2} + \binom{2m-1}{3}\frac{E_{m-2}}{2^3} + \cdots + (-1)^{m-1}\binom{2m-1}{2m-2}\frac{\beta_1}{2^{m-2}} + (-1)^m\binom{2m-1}{2m-1}\frac{E_0}{2^{2m-1}} + \frac{(-1)^m}{2^{2m-1}} = 0. \qquad (A'')$$

From formula (B) we get

$$2^{2m}\binom{2m+1}{1}B_m - 2^{2m-2}\binom{2m+1}{3}B_{m-1} + \cdots + (-1)^{m-1}\binom{2m+1}{2m-1}2^2B_1 + (-1)^m 2m = 0. \qquad (B')$$

Formula (C) gives

$$2^{2m}(2^{2m}-1)B_m - \binom{2m}{2}2^{2m-2}(2^{2m-2}-1)B_{m-1} + \cdots + (-1)^{m-1}\binom{2m}{2m-2}2^2(2^2-1)B_1 + (-1)^m 2m = 0.* \qquad (C')$$

* These four formulae are taken from the above mentioned work by Dr. Saalschütz, the following sections and paragraphs: (A'), Abschnitt I, § 4, formula XIX_a; (A''), formula XIX_b; (B'), Abschnitt I, § 2, formula V; (C'), Abschnitt I, § 2, formula VII.

The notation $\binom{n}{r}$ here stands for the binomial coefficient

$$\frac{n(n-1)\cdots(n-r+1)}{r!}.$$

It will be seen that these formulæ do not offer any advantage over (A), (B) and (C) in computing the coefficients of π^m. (D) is not easily reducible in terms of B_m and E_m except for certain values of r.

Proof that $(\sigma_1')^2$ *is Convergent.* — The series formed by taking the product $\sigma_1' \times \sigma_1'$ according to Cauchy's multiplication rule will be

$$\sum_1^\infty (-1)^{n-1}\left[\frac{1}{1\cdot(2n-1)}+\frac{1}{3(2n-3)}+\frac{1}{5\cdot(2n-5)}+\cdots+\frac{1}{(2n-1)\cdot 1}\right]. \tag{42}$$

Since the terms of this series are alternately positive and negative, it will be convergent if each term be numerically less than the preceding, and the limit of the nth term be zero as n increases indefinitely. If u_n and u_{n+1} represent the nth and $(n+1)$th terms respectively, there will be n terms in u_n and $n+1$ in u_{n+1}. Writing out the nth term, and showing the middle terms of the expression, we will have for the value, regardless of sign,

$$\frac{1}{1\cdot(2n-1)}+\frac{1}{3(2n-3)}+\cdots+\frac{1}{(n-2)(n+2)}+\frac{1}{n^2}+\frac{1}{(n+2)(n-2)}+\cdots+\frac{1}{(2n-1)\cdot 1}, \tag{43}$$

if n be odd, or

$$\frac{1}{1\cdot(2n-1)}+\frac{1}{3(2n-3)}+\cdots+\frac{1}{(n-1)(n+1)}+\frac{1}{(n+1)(n-1)}+\cdots+\frac{1}{(2n-1)\cdot 1}, \tag{44}$$

if n be even.

If we decompose the fractions, we get from (43)

$$\frac{1}{2n}\left[1+\frac{1}{2n-1}+\frac{1}{3}+\frac{1}{2n-3}+\cdots+\frac{1}{n}+\frac{1}{n}\right.$$
$$\left.+\cdots+\frac{1}{2n-1}+1\right], \tag{45}$$

or from (38)

$$\frac{1}{2n}\left[1+\frac{1}{2n-1}+\cdots+\frac{1}{n-1}+\frac{1}{n+1}+\frac{1}{n+1}+\frac{1}{n-1}\right.$$
$$\left.+\cdots+\frac{1}{2n-1}+1\right]. \tag{46}$$

In either case, by combining the fractions equally distant from the ends, we obtain,

$$\frac{1}{n}\left[1+\frac{1}{3}+\frac{1}{5}+\cdots+\frac{1}{2n-1}\right], \tag{47}$$

a more convenient form for the value of the nth term of the product.

If the absolute value of each term is to be less than that of the one preceding it, we must always have $u_n > u_{n+1}$, that is,

$$\frac{1}{n}\left[1+\frac{1}{3}+\cdots\frac{1}{2n-1}\right] > \frac{1}{n+1}\left[1+\frac{1}{3}+\cdots+\frac{1}{2n+1}\right],$$

or,

$$\left[\frac{1}{n}-\frac{1}{n+1}\right]\left[1+\frac{1}{3}+\cdots+\frac{1}{2n-1}\right] > \frac{1}{(n+1)(2n+1)},$$

$$\frac{1}{n(n+1)}\left[1+\frac{1}{3}+\cdots+\frac{1}{2n-1}\right] > \frac{1}{(n+1)(2n+1)},$$

$$\therefore \frac{2n+1}{n}\left[1+\frac{1}{3}+\cdots+\frac{1}{2n-1}\right] > 1.$$

But this last is evidently true for all positive integral values of n, therefore the first condition for convergency is satisfied.

We will now consider the limit of the expression

$$\frac{1}{n}\left[1+\frac{1}{2}+\frac{1}{3}+\cdots+\frac{1}{2n-1}\right] \tag{48}$$

as n increases indefinitely. The expression in brackets is known to be equal to $C + \log(2n-1)$, where C lies between 1 and 0 for all values of n, and has as its limit, when n is increased indefinitely, Euler's constant.* Calling the expression in (47) v_n we have, therefore,

$$v_n = \frac{C}{n} + \frac{\log(2n-1)}{n}. \tag{49}$$

Each of the terms on the terms on the right-hand side approaches zero as a limit when we increase n.† Now if

$$u_n = \frac{1}{n}\left| 1 + \frac{1}{3} + \frac{1}{5} + \cdots + \frac{1}{2n-1} \right|, \tag{50}$$

u_n is always less than v_n and therefore must approach the limit zero. Both conditions for convergency thus being satisfied, the series formed by squaring σ_1' according to Cauchy's rule, converges to the limit $(\sigma_1')^2$.‡

* CHRYSTAL: *Alg.*, Vol. II, Chap. XXV, § 13, Cor. 7, Example, p. 81.
† CHRYSTAL: *Alg.*, Vol. II, Chap. XXV, § 15, p. 85.
‡ CHRYSTAL: *Alg.*, Chap., XXVI, § 20, Cor. p. 135.

STUDENT WORK ON SUNSPOTS AND SOLAR ROTATION.*

F. H. Loud.

The course entitled Astronomy B, as given at Colorado College, consists of observations, made with the 4-inch equatorial and the 2-inch transit and any other available instruments, together with simple computations based on the observations. Different members of the class are assigned different subjects for observation, and some of these subjects are worked up by the observers alone, others are given the common attention of the class. The mathematical prerequisite terminates with plane trigonometry, but the principal formulæ of spherical trigonometry are made a part of the course, which is completed by the preparation of essays on the subject studied.

The sunspot maximum of the current year was made the occasion for a study of the time of the sun's rotation and the direction of the solar axis in space, these being taken as unknown quantities, to be determined, as well as might be, by the original effort of the class. This method is the one adopted whenever practicable, as probably better adapted to stimulate the imagination than that of assuming the results obtained by astronomers. The subject just mentioned is especially suited to awaken an amateur interest, as the sunspots have a voluminous semi-popular literature, while at the same time their nature is enveloped in a veil of mystery, as yet but partially lifted by the efforts of science. In like manner the solar rotation, from its relation to the nebular hypothesis, is connected with another class of unresolved and thought-provoking problems. It has been considered possible, in view of these same elements

* Observations by Mr. Orrie Stewart. Computations by Instructor and Class.

of general interest, that a review of the methods used by the class, and the degree of their success, though but moderate, may be acceptable in a wider circle, among the friends of the College.

The point on the celestial sphere toward which the northern end of the solar axis is directed must have been, if the hypothesis of LaPlace is correct, originally coincident with the pole of the "invariable plane" of the system, or substantially with that of the earth's orbit, in right ascension 18 hours, declination 66° 33′. Its actual position, the object of our inquiry, is stated by Young,* as R. A. 19h., dec. 63° 48′, with the remark that "different investigators get slightly different values.† When it is considered that any of these values is doubtless the result of averaging hundreds of separate determinations, it is quite apparent that deductions from the movements of a single spot may be expected to vary widely from the mean, quite independently of those uncertainties which the limitations, either of instrumental efficiency or of observing skill, may introduce.

Each observation is expected to furnish the position of a spot on the sun's surface at a known moment, and this position is most conveniently stated by naming (1) the ratio, d/r, which the apparent distance of the spot from the center of the disk bears to the whole radius of that disk, and (2) the angle E which the radius bearing the spot makes at the center with a line drawn toward the celestial pole. To obtain these quantities two methods of observation were used. The one most in favor with the class consisted in projecting the image of the sun on a sheet of paper ruled in squares, at such a distance

* *Manual of Astronomy*, page 201.

† The English annual, *The Companion to the Observatory*, employs as the basis of its ephemeris an inclination of 7° 15′ to the ecliptic, with longitude of ascending node 74° 26′. This amounts to placing the pole of rotation in R. A. 19h. 3.7m., dec. 63° 43′. A German value of the same elements, quoted by *Popular Astronomy* for May, 1905, (p. 282), is 6° 58′ with node at 74° 34′ — equivalent to putting the pole at R. A. 19h. 1.6m., dec. 63° 52′.5. Other authors give slightly varying values — *e. g.*, Newcomb and Holden's *Astronomy* states the inclination at 7° 9′ — but the above fairly indicates the range of uncertainty permitted by the best determinations.

from the eyepiece of the equatorial that the entire disk appeared as a circle of six inches diameter. As these observations were not taken precisely at noon, the direction of the meridian across the disk was ascertained by detaching the equatorial from the driving-clock, and placing one system of rulings in the direction of the apparent motion of the image. A pencil-sketch of the image was then made on a similar sheet of ruled paper, the position of each spot sketched being fixed with as much accuracy as possible by means of the small squares. The two quantities d/r and E were afterward measured from the sketch by the aid of an ordinary rule and protractor.

Another method of obtaining the same quantities was believed at the time to be more accurate, but was not always available, as it requires observations at the moment of the sun's crossing the meridian — too often (even in Colorado), interrupted by clouds — and moreover can be employed only upon spots so large as to be seen in the smaller transit instrument. The reticule of this instrument contains, beside the customary horizontal and five vertical threads, one which crosses the field of view diagonally, at an angle with the horizontal wire of about 27°. An ordinary observation consists in noting the times, by the sidereal clock, when the preceding and the following limbs are respectively tangent to the diagonal wire and to each of the vertical wires, the horizontal wire having been first placed so as approximately to bisect the disk, and the corresponding altitude having been read on the vertical circle. When a spot is seen, the time of its passage over the diagonal wire must certainly be noted, and, in addition, that of its crossing one or more (as many as convenient) of the vertical wires. A theoretically complete observation would include the transits of all five of these wires, but it is not best to attempt this at the risk of becoming confused in making so many entries at irregular intervals. A short calculation then gives the angle and ratio desired.*

* The process is as follows: Let the observed data be: v, the reading of the vertical circle; p_1, p_2, · · ·, p_5 and p_d, the clock times of contact of the preceding limb with the five vertical and one diagonal wire; f_1, · · ·, f_5 and f_d the

Having then two data for each of several observations of the same spot on different days, the next question is the most convenient method of using them to determine the position of the axis. The plan at first tried was to transfer all the observed places to one drawing, and then by trial to find an ellipse, tangent near each extremity to the disk, which would most nearly pass through all the places. The ratio of the axes of this ellipse was taken to determine the angle made by the sun's axis with the line of sight to the middle of the path, while the angle of the minor axis with the N. and S. line was to be the inclination of two planes meeting on this line of sight, the one a meridian of the earth, the other of the sun. This construction evidently involves some vicious assumptions — in particular, that all the observed places may be regarded as viewed from one position of the earth. Whether from this cause

corresponding times for the following limb ; $s_1, \cdots, s_5$ (or so many of them as may have been observed) and s_d, the corresponding clock times for the spot. Then $\frac{1}{5}(p_1 + p_2 + \cdots + p_5) = p_m$ the time of contact of the preceding limb with the mean wire, and similarly f_m is obtained for the following limb, while $\frac{1}{2}(p_m + f_m) = c_m$, the clock time of transit of the sun's center. This, corrected for clock error, is the observed right ascension of the sun, while $v - 51° \; 9'$ (the colatitude) is δ, the observed declination. Similarly $\frac{1}{2}(p_d + f_d) = c_d$, the time that the sun's center reaches the diagonal wire. To obtain s_m (the time the spot passes the mean wire) suppose s_3 and s_5 to have been observed. Then $\frac{1}{2}(p_3 + f_3) - s_3$ and $\frac{1}{2}(p_5 + f_5) - s_5$ are two determinations of the interval at which the spot follows the sun's center, and the mean of all such determinations is the accepted value of that quantity, designated as x_t. Then $c_m + x_t = s_m$. The subscript t denotes that the unit of measure of a quantity is the second of time, or the space passed over in a second by a point in the observed disk. Any distance measured in this unit can be converted, if desired, into seconds of arc by multiplying by 15 cos δ; but this reduction is not necessary for the present purpose. Thus if r represent the sun's semidiameter, $r_t = \frac{1}{2}(f_m - p_m)$ and r'' would be 15 r_t cos δ. So $q_t = \frac{1}{2}(f_d - p_d)$, the distance traversed by the sun's center between the moments of contact of the two limbs with the diagonal wire. If i be the angle made by the diagonal with the horizontal wires (an instrumental constant) i is determined by the equation sin $i = r/q$. Let k denote the quantity $(s_d - s_m) - (c_d - c_m)$, then k tan i is y_t, where x and y are the coordinates of the spot's position on the solar disk. The quotient $x/y =$ tan E, where E is one of the two quantities sought, and x_t cosec $E = y_t$ sec $E = d_t$, the spot's distance from the center. Finally d/r is the ratio required as the other of these two quantities.

alone or from other inherent inaccuracies, it wholly failed to give any passable determination of the direction of the solar axis. One result only was gained from it — it was possible to interpolate upon the diagram so as to obtain pretty accurately the hour of the spot's nearest approach to the center of the disk. In case this could be done on two successive returns of the same spot, the synodic period, and thence the true time of rotation could be deduced, in better conformity to accepted results than was achieved in any other way.

The failure of the graphic plan led to the conclusion that the successive observed places of the spot must be referred to a fixed system — in short, that it was necessary to reduce each observation so as to derive from it the heliocentric right ascension and declination of the spot. If, from the sun's center, three lines go forth, the one parallel to the earth's axis, the next pointing to the spot, and the third to the earth, they meet the celestial sphere in three points, N, S, and E, the first of which is the north pole of the sphere — the ordinary north pole near Polaris — while the last is diametrically opposite to the known position of the sun as seen from the earth. Accordingly an angle and two adjacent sides of the triangle are known: the angle E is that which has been so designated hitherto; the side ES is that which has the ratio d/r for its sine; while EN is $90° + \delta$, where δ represents the sun's declination, taken with its proper sign. From these data the angle N and the side NS are found. The former added (with due attention to sign) to the right ascension of E, gives that of S; the latter is the complement of the same point's declination.

The heliocentric position of the spot at each observation being now known, it would, perhaps, seem appropriate to reduce each to three coördinates, x, y and z, and seek, by the solution of linear equations, the unknown coefficients of the equation of a plane $Ax + By + Cz = 1$, which should contain all the given points. This method would be well adapted to an illustration of the process of least squares. But the mathematical equipment of the majority of the class was insufficient for this attempt, and a purely trigonometrical procedure was adopted.

Three of the observed places were selected, respectively near the beginning, middle and end of the period during which the spot remained visible, and the sides and angles of the triangle formed by them were computed. This, of course, requires the solution of three triangles, in each of which a pair of the selected places form two vertices, and N is the third. The triangle of places being completely known, it is a simple matter to deduce the distance and direction from any vertex to the pole, P, of the circumscribed small circle.* The solution of one more triangle, having one vertex in common with the last, and N and P for the other two, leads to the distance NP, the polar distance of the required point, and to the angle at N which makes known its right ascension.

The required determination has now been made, but only on the basis of three observations of the spot. The process may be repeated with a new selection of three observations, or in case only four or five are available in all, it may suffice to calculate the distance from P to each remaining place, which ought to agree with its distance from those used in the computation.

Still another check is now available — like the last mentioned, a test not so much of the accuracy of the computing as of the quality of the observations. The angles at P, formed by the solar meridians passing through the observed places of the spot, should be proportional to the intervals of time between the observations, and the speed of rotation thus derived should yield a determination of the true or sidereal period. This requirement appears to be a difficult one, and while some determinations of the position of the axis have been fairly good, it is only by the aid of spots that have made two appearances near the center of the disk that we have been able to get

* On a semi-circumference of a small circle, let A, B, C, be three points taken in that order, and let P be the pole of the circle, exterior to the triangle ABC. Then, since $PAB = PBA$, $PBC = PCB$, $PCA = PAC$, while $A = PAB - PAC$, $B = PBA + PBC$, $C = PCB - PCA$, it follows that $\frac{1}{2}(A + B + C) = S = PAB + PBC - PCA$, or $PAB = S - C$, $PBC = S - A$, $PCA = B - S$. If P be the more remote pole of the small circle (as when the latter is south of the sun's equator), the angles PAB, etc., in the above equations must all be replaced by their supplements.

results for the rotation-period that can be regarded as even nearly satisfactory.

Examples of the two methods of observation employed — those of drawings made by aid of the equatorial and of time-observations with the transit — are furnished respectively by the great spot of January–March, 1905, which appeared in the southern hemisphere, and by a northern spot seen during part of the interval in which the former was hidden on the further side of the sun. The former was observed four times during its first appearance, on January 30 and February 1, 6 and 9; and six times in its second circuit, February 27 and March 2, 4, 6, 7 and 8. Its calculation was left entirely to the result of drawings. From these it was taken to have approached most nearly the center of the disk at about 6:30 P. M. February 3 and 8:20 A. M. March 3. The interval is 27 days $13\frac{5}{6}$ hours, or $27^d.575$. This synodic period corresponds to $25^d.64$ * as a sidereal time of rotation. From the first, second and fourth observations of the first set, it was inferred that the spot was in south latitude 13° 35′ and the position found for the pole was R. A. $18^h\ 45.^m1$, dec. + 63° 3′. The distance from this position, however, to the spot as seen at the third observation was 106°, or two degrees and a half too great. The six observations of the spot's second passage were arranged in two triangles, the first, third and fifth in one, the even numbers in another. The latitudes now came out greater than before, viz.: $15\frac{1}{2}$ and $20\frac{1}{2}$ degrees of south latitude. The pole, by the odd triangle, was computed to be in $18^h\ 35^m.5$ + 61° 41′; by the even triangle, in $19^h\ 31^m$ + 59° 8′. In view of the large discrepancies in right ascension, it could not be expected that the speed of rotation, as deduced from these triangles, should yield accordant results. The period obtained was in fact always too large.

The northern spot already mentioned, though selected to represent the method of observation with the transit instrument, because of the greater approach to completeness manifested in the original observation, did not make good the

* In solar latitude 15°, the average motion of the spots indicates, according to Carrington, a rotation-time of 25.5 days.

expectation of greater accuracy which that method was believed able to yield. There was, indeed, a handicap in this case, because the four observations were all comprised within a short time, being taken on February 10, 13, 14 and 15. The first, second and fourth were combined in a triangle, the pole of whose circumscribed circle was found to be 74° 12′ from the vertices, and nearly 76° from the third observed position. So far, the measures were accordant, but the coördinates of this pole came out 19^h $34^m.8$ in right ascension, and 55° 28′ in declination. At the same time, the angles at the pole, formed by lines drawn to the vertices, were found to be 28° 21′, 65° 34′, 37° 13′, which are but very roughly in agreement with the ratio of the times, 2 : 5 : 3.

The result of the experiment is therefore in favor of the method of sketching, as adopted in the case of the great spot, which by an average of the three determinations drawn, as above, from its observed places, locates the sun's pole in right ascension 18^h $57^m.2$ and declination 61° 17′,—or not farther from the position adopted by the best astronomical authorities, than half the distance which separates the two "pointers" in Ursa Major.

THE GREAT SUNSPOT OF JANUARY--MARCH, 1905.

By F. H. Loud.

One of the spots which was made the subject of the measurements described in the foregoing paper proved so noteworthy in itself, that it has seemed desirable to devote to it a brief descriptive account. The same spot, indeed, was regarded with especial interest at larger observatories, and was reported at some length in an article contributed by Mgr. Spée, Astronomer at the Royal Observatory of Belgium, at Uccle, to the monthly publication of the Belgian Astronomical Society. That article has been freely used in the present account, so that facts for which the Colorado College observations are not expressly cited may be in general credited to the Belgian authority.

The spot was observed at Colorado Springs a little earlier than at Uccle, in consequence of bad weather prevailing on the European continent. The Colorado sky in late winter and spring is not faultless, and frequently baffled attempts to observe, but the Belgian astronomers fared far worse than we. Our first view was obtained on January 30, theirs on the 31st, when it was computed that the new phenomenon was three days' journey, or more, within the eastern limb. It was described as "a vast region, rather rectangular than elliptical, divided into fragments by canals more or less luminous, and enclosing a multitude of nuclei, unequally distributed and varying in size." It occupied a position nearly coincident with that of a small spot observed one rotation-period earlier, or between the seventh and thirteenth of the month, which had shrunk, before passing off the disk, to the dimensions of a barely visible pore.

On the first of February, the spot was sketched at Colorado

Springs, but was again hidden from the Belgian observers, who, however, succeeded in making a drawing the next day. A comparison of the two representations is interesting, especially in view of the discrepancy in the instrumental power employed. The Belgian drawings are made by the aid of an eye piece which presents an image of the sun of 35 centimeters, or almost 14 inches, in radius. The solar image as seen at Colorado Springs, displayed upon a sheet of white paper, had a radius of 3 inches only. Naturally the detail is much fuller in the former.

The Belgian observers were more fortunate than we in the matter of observations near the centre of the disk. The spot made its transit of the central meridian on the fourth of the month, and was carefully measured on that day at Uccle, but remained unobserved at Colorado Springs from the second to the sixth. The results of the measure just mentioned were to fix its dimensions as seen from the sun's centre at 12° 47′ east and west, and 7° 42′ north and south, answering to a length and breadth of 215″ and 130″ respectively, as seen from the earth. The total area was one one-hundred and seventy-second part of the disk, which, Mgr. Spée says, entitles it to a rank of third among those measured since telescopic observations began. Those of November 8, 1787 and September 30, 1858, surpass it so far, that it seems strange if none intermediate in magnitude have been observed, for their lengths are given as 274″ and 302″ respectively. But this of 1905 was large enough to accommodate within its area ninety globes of the size of the earth placed side by side!

As noted in the preceding paper, this spot returned to view in the latter part of February, and was observed through a second transit of the disk, retaining its characteristics of form, though somewhat diminished in size and intensity. After its second disappearance it was not again recognized at Colorado Springs, though at the observatory at Uccle it was seen still further attenuated during a third transit, the passage of the central meridian occurring on March 31.

SOLUTION OF NUMERICAL CUBIC EQUATIONS.

By F. H. Loud.

The solution of any cubic equation may, by well known methods, be made to depend on that of an equation in the form

$$y^3 + my = 1 \qquad (1)$$

where, if the original equation were

$$ax^3 + bx^2 + cx + d = 0$$

the value of m is given by the formula

$$m = 3(3ac - b^2)\left[2b^3 - 9abc + 27a^2d\right]^{-\frac{2}{3}}$$

and the dependence of the root of one equation upon that of the other is expressed as follows:

$$x = -\frac{b}{3a} - \frac{y}{3a}\left[2b^3 - 9abc + 27a^2d\right]^{\frac{1}{3}}.$$

The equation (1) has always one positive root; the other two roots may be either negative or imaginary.

By Cardan's method, the value of y may be found as an algebraic function of m, viz.,

$$y = \left[\tfrac{1}{2} + \tfrac{1}{18}\sqrt{81 + 12m^3}\right]^{\frac{1}{3}} + \left[\tfrac{1}{2} - \tfrac{1}{18}\sqrt{81 + 12m^3}\right]^{\frac{1}{3}}. \qquad (2)$$

For example, the following equation may be employed; constructed as it is (with some pains) to ensure a rational value of m, as well as a real value of $\sqrt{81 + 12m^3}$.

$$2x^3 - 15x^2 + 97x + 70 = 0.$$

This depends as above for its solution upon

$$y^3 + 1.19y = 1$$

and we shall have $x = 5(\frac{1}{2} - y)$.

Here $81 + 12m^3 = 101.221908$, so that

$$y = \sqrt[3]{1.058939438+} + \sqrt[3]{-0.058939438+}$$
$$= 1.019272 - 0.389166$$

or $y = 0.630106$ whence $x = -0.65053$.

This result may be verified by applying Horner's method to the original equation. Such a trial will exhibit the great superiority of the latter process, for numerical work, even in an example specially framed in favor of the former.

But while the solution of a single example, independent of all others, is best effected without a reduction to the form (1), yet this reduction might be made useful in obtaining the roots of cubic equations by means of tables. In that case, with all possible values of m as argument, the corresponding values of y would be tabulated; these being in reality the values of the function (2), even though not obtained by computations based upon that form. Here m becomes the independent variable, and if replaced in notation by x, the equation

$$y^3 + xy = 1$$

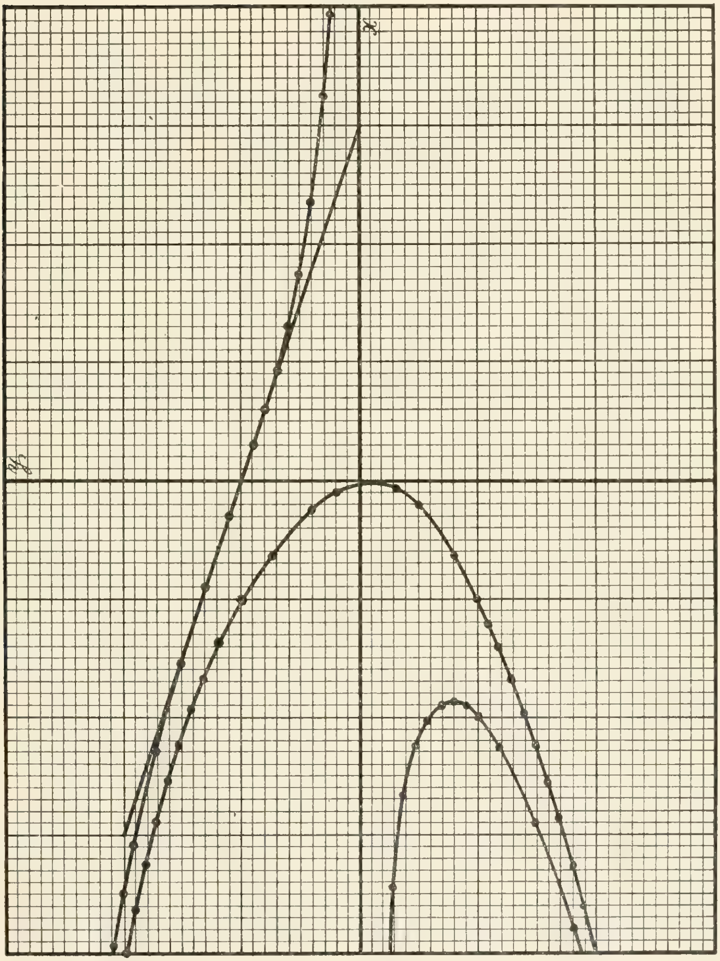
represents a curve, the ordinates of which, at points whose abscissas are separated by equal distances, are the quantities to be tabulated; being roots of successive forms of equation (1).

This curve is a cubic of the crunodal genus, being accordingly* of the fourth order with three points of inflection, only one of which † is real. It is of the species known as the *trident*, ‡ the double point being situated at the intersection of the axis of abscissas with the line at infinity, and having those two lines as nodal tangents. The inflection is at the point $x = 0$, $y = 1$, and the tangent there is $x + 3y - 3 = 0$. The axis of abscissas is an asymptote to the curve; and the latter has also a parabolic asymptote, viz., the conic parabola $x + y^2 = 0$. For every real value of x there is one and only one value of y, that is real and positive, and the points corresponding to these make up the upper branch of the curve, which approaches the axis for large positive values of x, and the parabola for large negative values. The lower branch, lying wholly to the left

* Salmon, H. P. C., p. 129.

† *Idem*, p. 184.

‡ *Idem*, p. 176.


x
y

of the line $x = -\sqrt[3]{\frac{27}{4}}$, exhibits the case of two additional real roots, both of which are necessarily negative.

The equation of the curve permits the abscissa of any point to be expressed as a function of the ordinate, viz.,

$$x = \frac{1 - y^3}{y}.$$

Accordingly, the equation of a right line joining two points

$$y = \frac{y_2 - y_1}{x_2 - x_1} x + \frac{x_2 y_1 - x_1 y_2}{x_2 - x_1}$$

becomes the equation of a chord when x_1 and x_2 are replaced by their values according to this formula. This equation is

$$y = \frac{y_1 + y_2 + y_1^2 y_2^2}{y_1 y_2 (y_1 + y_2) + 1} - \frac{y_1 y_2 x}{y_1 y_2 (y_1 + y_2) + 1}.$$

If the two points coincide, the equation of the tangent results, viz:

$$y = \frac{2y_0 + y_0^4}{2y_0^3 + 1} - \frac{y_0^2}{2y_0^3 + 1} x.$$

If a value of x be taken corresponding to a point intermediate between two points of known ordinates, y_1 and y_2 (these points being both on the same side of the point of inflection) then these formulæ give the ordinates of points corresponding to x, one on the chord, the other on the tangent; and the point on the curve, with the same abscissa, must lie between these two.

In using these formulæ to compute tables, y_1 and y_2 are first given values at such a distance apart as may seem convenient, and y_0 is chosen nearly midway between them. As a result, the chord and tangent are approximately parallel. Then x is given a series of equidistant values, intermediate between those corresponding to y_1 and y_2. The corresponding ordinates of the chord are in arithmetical progression, consequently the values of (say) ten of them are written down with little more labor than is requisite for any two. The same is true of the corresponding values of the tangent. So far as the figures expressing an ordinate of the chord coincide with those of the corresponding tangent-ordinate, they are correct also for the intermediate value of the ordinate of the curve. The approximation made in this way will not, however, in the first instance be very close. A second calculation is based upon the first, by taking for values of y_1 and y_2 two successive values of the curve-ordinate as just found — or, if it be more convenient, two numbers that differ but little from these — and assuming a new series of values of x, with a common difference much smaller than before, for instance, one-tenth as large. By repeating this procedure, the computation may be carried to whatever degree of approximation may be desired.

The compactness of the tables and the consequent facility of their use requires that the rate of change of the function as compared with that of the argument be slow. To secure this, it would probably be well to break up the tables into three parts, the range of value of the argument (the abscissa) in one part being from $+3$ (or thereabout) indefinitely toward $+\infty$, in another part between $+3$ and -3, while still another (overlapping the preceding by a little) comprises the negative values below $-\sqrt[3]{\frac{27}{4}} = -1.88988$.

In the first-named section, the tabulated function should be the ordinate of the curve as just described; in the next, it should be the difference between that ordinate (that is, that of the upper branch) and the ordinate of the inflectional tangent; while the remaining section, dealing with those abscissas which furnish three real roots, should contain tabulated values of the difference between the ordinates of the curve and those of the parabolic asymptote.

If this plan were to be carried out, the most rapid change in the function would occur in the neighborhood of the value 3 of the argument, and here accordingly the tabulation would appear under the least favorable conditions. The appended numerical data, constituting a computation of a fragment of the proposed table, in the region just mentioned, will suffice to show the method, and indicate how much rapidity of approximation may be expected. To obtain the first set of rough values, when x increases by steps of 0.1 from 3.0 to 6.0, four sets of chord and tangent were employed. For $x = 3.0$, 3.1

and 3.2, y_1 was put equal to 0.325, y_2 to 0.3, and y_0 to 0.31. From $x = 3.3$ to $x = 3.9$, y_1 was 0.3, y_2 was 0.25 and y_0 was 0.28. Then from $x = 4.0$ to $x = 4.9$, the values of the three y's were 0.25, 0.2 and 0.22; and from $x = 5.0$ to $x = 6.0$ they were 0.2, 0.16 and 0.18.

The first step of this progression was then retraced with a lower common difference, so as to insert ten steps of 0.01 each between $x = 3$ and $x = 3.1$. Here y_1 was put equal to 0.3225, y_2 to 0.3125, and y_0 to 0.3175. Again, to divide the first step of this again into ten, making x equal successively to 3.000, 3.001, · · · 3.010, the assumed extreme ordinates were $y_1 = 0.3222$, $y_2 = 0.3212$, $y_0 = 0.3217$. The following were the computed ordinates of chord and tangent.

Abscissas.	Ordinates.	
	Chord.	Tangent.
3.0	0.3223	0.3217
3.1	.3131	.3126
3.2	.3039	.3035
3.3	.2959	.2944
3.4	.2887	.2869
3.5	.2815	.2794
3.6	.2743	.2719
3.7	.2671	.2644
3.8	.2599	.2569
3.9	.2527	.2494
4.0	.2469	.2435
4.1	.2420	.2388
4.2	.2371	.2340
4.3	.2322	.2293
4.4	.2273	.2246
4.5	.2224	.2198
4.6	.2175	.2150
4.7	.2126	.2103
4.8	.2077	.2056
4.9	.2028	.2008
5.0	.1987	.1967
5.1	.1956	.1935
5.2	.1924	.1903
5.3	.1893	.1871
5.4	.1861	.1839
5.5	.1829	.1807
5.6	.1798	.1775
5.7	.1766	.1743
5.8	.1734	.1711
5.9	.1703	.1679
6.0	.1671	.1647

Abscissas.	Ordinates.	
	Chord.	Tangent.
3.00	0.32219	0.32212
3.01	.32125	.32117
3.02	.32030	.32022
3.03	.31935	.31928
3.04	.31841	.31833
3.05	.31746	.31738
3.06	.31651	.31643
3.07	.31556	.31549
3.08	.31462	.31454
3.09	.31367	.31359
3.10	.31272	.31264
3.000	0.3221854	0.3221847
3.001	.3220884	.3220877
3.002	.3219913	.3219906
3.003	.3218943	.3218936
3.004	.3217972	.3217965
3.005	.3217002	.3216995
3.006	.3216032	.3216025
3.007	.3215061	.3215054
3.008	.3214091	.3214084
3.009	.3213120	.3213113
3.010	.3212150	.3212143

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THE MAMMALS OF COLORADO,

BY

EDWARD R. WARREN.

COLORADO SPRINGS, COLORADO

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SCIENCE SERIES.

(*Continued on inside of back cover.*)

THE MAMMALS OF COLORADO.

By Edward R. Warren.

In this paper the writer has attempted to give as complete a list of the Mammals of Colorado as possible, but only those who have worked on such lists know how difficult it is to gather the information necessary to make it full and correct, and especially in this case has it been hard to secure much desired data. The workers on the mammals are so few, and Colorado is so large and covers such a variety of conditions of surface and climate that a great deal is yet to be learned about our mammals, both as to the species occurring and as to their distribution; indeed, it is facts bearing on the latter subject that are most to be desired. In a number of cases the only records of the occurrence of a certain species, aside from those given in some number of the *North American Fauna,* for instance, are the writer's, obtained in such little collecting as he has done in a few localities.

I cannot do better than to quote from Professor Cooke's "Birds of Colorado" his description of the surface of the State, as it covers the ground so well, and only needs the word "bird" to be changed to "mammal" occasionally to fit the case exactly:

"The broken character of the surface of Colorado offers inducements for birds of all kinds. The eastern third of the State is a vast plain, rising from an altitude of 3,500 feet at its eastern edge to nearly 6,000 feet, where it joins the foothills of the Rockies. This whole region is treeless, except a narrow fringe along the streams. . . .

"The center of the State is occupied by the Continental Divide. Range on range attaining a height of over 14,000 feet offers favorable conditions for even boreal species. The great mountain parks lie in this section, and at an altitude of

8,000 feet mark the limit of height reached by the great bulk of the species. (This last refers, of course, especially to birds.—E. R. W.)

"The western third of Colorado presents a wilderness of rolling hills from 5,000 to 8,000 feet in altitude, covered with a few trees and a very scanty vegetation. . . ."

With such a variety of country, it is not surprising that we have one hundred and seventeen species and subspecies of mammals to record, with a large area all around our borders as yet unworked, to say nothing of the interior of the State. In the region about Colorado Springs, including, of course, the Pike's Peak region, there are over fifty species of mammals to be found, varying from such typical arid land forms as the Kangaroo Rats and Pocket Mice to the Alpine and Arctic "Conies" or Pikas (*Ochotona*). One could work for years in this region alone studying the distribution of the different species without exhausting the subject.

To quote Professor Cooke again, "There is no State in the Union that offers a more difficult field for thorough work, and a recapitulation of our present knowledge only serves to bring out more clearly the many points on which more information is needed." In the following pages I call attention to many such points. The very fact that many species of mammals are practically stationary in their residence renders it all the harder to secure all the species when some are confined to small areas. The distribution is often difficult to work out in the cases of the higher ranging forms, whose habitats are broken in continuity by the valleys and parks between the different mountain chains.

The literature of the subject is quite limited, the only list that I know of being that of Dr. Elliott Coues in an appendix to Mary Dartt's "On the Plains and Among the Peaks," which was a description of the collection gathered by Mrs. Maxwell, and which was published in 1879. This list named 47 species. I am indebted to Judge Junius Henderson of Boulder for the loan of a copy of the book, which is very scarce.

A number of species described by Say, Baird and others have their type localities in Colorado, and in various numbers of the *North American Faunas,* published by the Biological Survey of the U. S. Department of Agriculture, are references to the occurrence of a number of species in this State, and there also a number of such references in papers published in the proceedings of various scientific societies.

Much of the information embodied herein was gathered by correspondence with the few collectors, and with others, and I am grateful for the willing help that has been given me by all. I am especially indebted to Dr. C. Hart Merriam, Chief of the Bureau of the Biological Survey, for the identification of many specimens, and for much information and for many notes about numerous species. Indeed it is practically at his suggestion that the list was undertaken. Mr. W. L. Burnett of Fort Collins has rendered me much help, giving me information about the mammals of Fort Collins and Larimer county. He has taken much interest in this work, and has done all in his power to assist me. Mr. W. C. Ferrill, Curator, and Mr. Horace G. Smith, Assistant Curator, of the State Historical and Natural History Society, have cheerfully given me their help, permitting me to examine specimens, Mr. Ferrill kindly sending specimens to Washington for identification, and Mr. Smith has been most patient in answering numerous letters of inquiry. To Dr. J. A. Allen, of the American Museum of Natural History, New York; Dr. F. W. True, U. S. National Museum, Washington; Prof. D. G. Elliot, Field Columbian Museum, Chicago; C. E. Aiken, Colorado Springs; Fred M. Dille, Denver; Judge Junius Henderson, Boulder; C. H. Smith, Coventry, Colo.; R. H. Sullivan, U. S. Signal Service; Prof. A. E. Beardsley, Greeley; W. E. Wolfe, Wray; Dr. S. M. Bradbury, Dr. E. F. Eldredge and W. P. Ela of Grand Junction, I am under obligations for help and notes.

The writer would be grateful for any additional notes as to our mammals which any of his readers may be able to send him, both as to the distribution and habits of the species. Much collecting remains to be done before the ranges of many of our species can be correctly mapped. If our local ornithologists would only take enough interest to make even rough skins, accompanied by skulls, of the small mammals they may run across, especially the different mice, they would help a great deal.

The arrangement followed in the list is practically that of Elliot's Synopsis.

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This Bibliography is no doubt incomplete as the facilities at my command and the books and other publications relating to Colorado Mammalogy and accessible to me are rather limited, but I have given everything that has come to my notice, and in some cases have not been able to give the exact title of an article, but merely the reference, and the species to which it refers.

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Contains description of *Cratogeomys castanops*, type from near Las Animas, Colorado.

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Contains descriptions of *Cynomys gunnisoni* from Cochetope Pass, and *Perodipus montanus* from the San Luis Valley, in Colorado, these being the original descriptions in each case.

BAIRD, SPENCER F. Reports of Explorations and Surveys to Ascertain the Most Practicable and Economical Route for a Railroad from the Mississippi River to the Pacific Ocean. Made under the Direction of the Secretary of War in 1853-1856, According to Acts of Congress of March 3, 1853; May 31, 1854, and August 5, 1854. Vol. VIII. 4°. pp. I-XLVII, 1-757. Pl. I-LX. Washington, Beverly Tucker, Printer, 1857. (The Mammals of North America.)

Describes *Microtus modestus* from Saguache (Cochetope) Pass, Colorado.

BANGS, OUTRAM. Proc. New England Zoological Club. June 5, 1899. Vol. I, pp. 39-42. Descriptions of Two New Pikas from Western North America. By Outram Bangs.

Describes *Ochotona saxatilis* from Snowy Range, Montgomery, Park county, Colorado.

COOPER, C. A. The Big Game of North America. Its Habits, Habitat, Haunts, and Characteristics; How, When, and Where to Hunt It. Edited by G. O. Shields.

Includes an article on the Wolverine by A. C. Cooper which gives records of the animal in Colorado.

COUES, ELLIOTT, and J. A. ALLEN. See J. A. Allen and Elliott Coues.

COUES, ELLIOTT. List of Mammals in the Maxwell Collection, published as an Appendix in the following. The only thing in the way of a list of Colorado mammals which I have seen.

DARTT, MARY. On the Plains and Among the Peaks; or How Mrs. Maxwell made her Natural History Collection. By Mary Dartt. Philadelphia, Claxton, Remsen & Haffelfinger, 624, 626 & 628 Market Street, 1879.

Describes Mrs. Maxwell's work, and mentions different mammals in main part of book.

ELLIOT, D. G. A Synopsis of the Mammals of North America and the Adjacent Seas, by Daniel Giraud Elliot, F. R. S. E., etc., Curator of Department. Zoological Series. Vol. II. [Seal Field Columbian Museum, Chicago]. Chicago, U. S. A., 1901.

Colorado mentioned as included in the distribution of many species.

HOWELL, A. H. U. S. Department of Agriculture, Division of Biological Survey. North American Fauna No. 20. (Actual date of publication, August 31, 1901.) Revision of the Skunks of the Genus *Chincha*, by Arthur H. Howell, Assistant, Biological Survey. Prepared under the Direction of Dr. C. Hart Merriam, Chief of Division. Washington, Government Printing Office, 1901.

Gives Colorado references and records of various species.

HOWELL, A. H. Three New Skunks of the Genus *Spilogale*. Proc. Biol. Soc. Wash. Vol. XV, pp. 241-242. December 16, 1902.

Describes *Spilogale tenuis* from type taken at Arkins, Larimer county, Colorado.

MEARNS, E. A. Smithsonian Institution, United States National Museum. Proceedings of the United States

National Museum. Vol. XX. Published under the direction of the Smithsonian Institution. Washington, Government Printing Office, 1898. Preliminary Diagnoses of New Mammals of the Genera *Sciurus, Castor, Neotoma*, and *Sigmodon*, from the Mexican Border of the United States, by Edgar A. Mearns, M. D., Assistant Surgeon, United States Army.

Describes *Castor canadensis frondator*, giving Colorado as part of its range.

MERRIAM, C. HART. Abstract of a Study of the American Wood Rats, with Descriptions of Fourteen New Species and Subspecies of the Genus *Neotoma*. By C. Hart Merriam, Proc. Biol. Soc. Wash., Vol. IX, pp. 117-128. July 2, 1894.

Contains descriptions of *N. fallax*, from type taken at Gold Hill, and *N. orolestes* from type taken 20 miles west of Saguache.

MERRIAM, C. H. U. S. Department of Agriculture, Division of Ornithology and Mammalogy. North American Fauna No. 8. Published by Authority of the Secretary of Agriculture. (Actual date of publication, January 31, 1895.) Monographic Revision of the Pocket Gophers, Family *Geomyidae* (Exclusive of the Species of *Thomomys*) by Dr. C. Hart Merriam. Washington, Government Printing Office, 1895.

Gives Colorado references and records of various species.

MERRIAM, C. H. U. S. Department of Agriculture, Division of Ornithology and Mammalogy. North American Fauna No. 10. (Actual date of publication, December 31, 1895.) Revision of the Shrews of American Genera *Blarina* and *Notiosorex*. C. Hart Merriam. The Long-tailed Shrews of the Eastern United States, Gerrit S. Miller, Jr. Synopsis of the American Shrews of the Genus *Sorex*, C. Hart Merriam. Washington, Government Printing Office, 1895.

Describes in article last named a new subspecies (*Sorex tenellus manus*) from Estes Park, besides giving Colorado references and records of several other species.

MERRIAM, C. H. U. S. Department of Agriculture, Division of Ornithology and Mammalogy. North American Fauna No. 11. (Actual date of publication, June 30, 1896.) Synopsis of the Weasels of North America. C.

Hart Merriam. Washington, Government Printing Office, 1896.

Figures skull of *Putorius arizonæ* from a Boulder county, Colo., specimen.

MERRIAM, C. H. Preliminary Synopsis of the American Bears, by Dr. C. Hart Merriam. Proc. Biol. Soc. Wash., Vol. X, pp. 65-83. April 13, 1896.

Includes Colorado in range of *Ursus horribilis horriæus.*

MERRIAM, C. H. Revision of the Coyotes or Prairie Wolves, with Descriptions of New Forms, by C. Hart Merriam. Proc. Biol. Soc. Wash., Vol. XI, pp. 19-33. March 15, 1897.

Gives part of range of *Canis pallidus* (now known as *C. nebracensis*) as eastern Colorado.

MERRIAM, C. H. *Phenacomys preblei*, a New Vole from the Mountains of Colorado, by C. Hart Merriam. Proc. Biol. Soc. Wash., Vol. XI, p. 45. March 16, 1897.

Type of species taken on Long's Peak.

MERRIAM, C. H. Preliminary Revision of the Pumas (*Felis concolor* Group). By C. Hart Merriam. Proc. Wash. Acad. Sciences. Vol. III, pp. 577-600. Dec. 11, 1901.

Contains remarks on the Roosevelt series of *F. hippolestes* from Colorado.

MERRIAM, C. H. A New Bobcat (*Lynx uinta*) from the Rocky Mountains, by C. Hart Merriam. Proc. Biol. Soc. Wash. Vol. XV, pp. 71-72. March 22, 1902.

States that the species is in Colorado and Utah restricted to the mountains.

MERRIAM, C. H. Eight New Mammals from the United States. By C. Hart Merriam. Proc. Biol. Soc. Wash. Vol. XVI, pp. 73-78. May 29, 1903.

Contains description of *Putorius streatori leptus* from type taken at Silverton.

MERRIAM, C. H. New and Little Known Kangaroo Rats of the Genus *Perodipus*. By C. Hart Merriam. Proc. Biol. Soc. Wash. Vol. XVII, pp. 139-146. July 14, 1904.

Contains note on *P. montanus* Baird, the type locality of which is Fort Garland.

MILLER, G. S., Jr. Synopsis of the Voles of the Genus *Phenacomys*, by Gerrit S. Miller, Jr. Proc. Biol. Soc. Wash. Vol. XI, pp. 77-87. April 21, 1897.

Contains description of *P. preblei* from Colorado.

MILLER, G. S., Jr. U. S. Department of Agriculture, Division of Biological Survey. North American Fauna No. 13 (Actual date of publication, October 16, 1897). Revision of the North American Bats of the Family *Vespertilionidae,* by Gerrit S. Miller, Jr. Prepared under the Direction of Dr. C. Hart Merriam, Chief of Division of Biological Survey. Washington, Government Printing Office, 1897.

Gives Colorado references and records of a number of species.

OSGOOD, W. H. U. S. Department of Agriculture, Division of Biological Survey. North American Fauna No. 18. (Actual date of publication, September 20, 1900.) Revision of the Pocket Mice of the Genus *Perognathus,* by Wilfred H. Osgood, Assistant Biologist, Biological Survey. Prepared under the Direction of Dr. C. Hart Merriam, Chief of Division of Biological Survey. Washington, Government Printing Office, 1900.

Gives Colorado references and records of various species.

PALMER, T. S. Bulletin No. 8. Revised Edition. U. S. Department of Agriculture, Division of Biological Survey. The Jack Rabbits of the United States, by T. S. Palmer, M. D., Assistant Chief, Biological Survey. Washington, Government Printing Office, 1897.

Gives descriptions and ranges of the different species of Jack Rabbits, mentioning Colorado several times, also accounts of Jack Rabbit hunts.

PREBLE, E. A. U. S. Department of Agriculture, Division of Biological Survey. North American Fauna No. 15. (Actual date of publication, August 8, 1899.) Revision of the Jumping Mice of the Genus *Zapus,* by Edward A. Preble, Assistant in Biological Survey. Prepared under the direction of Dr. C. Hart Merriam, Chief of Division of Biological Survey. Washington, Government Printing Office, 1899.

Gives Colorado references and records of various species.

RHOADS, S. N. Synopsis of the American Martins. By Samuel N. Rhoads. Proc. Acad. Nat. Sci. Phila., May, 1902. Gives Colorado as part of range of *M. americana.* Also describes *Mustela caurina origenes* from type collected at "Marvine Mountain," (Garfield county?) by Ernest Thompson-Seton.

ROOSEVELT, T. With the Cougar Hounds, by Theodore Roosevelt. Scribner's Magazine, October and November, 1901.

The President's account of his hunt in Rio Blanco county. Gives measurements and weights of animals killed.

ROOSEVELT, T. The Deer Family, by Theodore Roosevelt, T. S. Van Dyke, D. G. Elliot, and A. J. Stone. Macmillan & Co., New York, 1902.

The part entitled "The Deer and Antelope of North America," by Theodore Roosevelt has various Colorado references.

ROOSEVELT, T. A Colorado Bear Hunt, by Theodore Roosevelt. Scribner's Magazine, October, 1905.

The President's account of his bear hunt in Colorado, in the spring of 1905.

SAY, THOMAS. Account of an Expedition from Pittsburgh to the Rocky Mountains Performed in the Years 1819 and 20 by Order of the Hon. J. C. Calhoun, Secretary of War; under the Command of Major Stephen H. Long. From the notes of Major Long, Mr. T. Say, and other gentlemen of the party. Compiled by Edwin James, botanist and geologist for the expedition. In two Vols. With an atlas. Vol. I (II). Philadelphia: H. C. Carey and I. Lea, Chestnut St., 1823. (All Colorado matter is contained in the second volume.) Original descriptions of *Callospermophilus lateralis* from Arkansas River, Colo., near Canon City; *Myotis subulatus* from near La Junta; *Eutamias quadrivittatus* from Rocky Mountains, about the sources of the Arkansas and Platte Rivers; *Citellus grammurus* from Purgatory Creek, Colo., Lat. 37° 32′, Lon. 103° 30′.

THOMAS, O. Article in Annals and Magazine of Natural History, 6th Series, XI, p. 406. May, 1893. Gives description of *Perognathus infraluteus*, from type taken at Loveland, Colo.

TRUE, F. W. Smithsonian Institution, United States National Museum. Proceedings of the United States National Museum. Volume XVII, 1894. Published under the Direction of the Smithsonian Institution. Washington, Government Printing Office, 1895. Diagnoses of New North American Mammals, by Frederick W. True, Curator of the Department of Mammals.

Describes at page 241 *Sciurus aberti concolor*; type from Loveland, Colo.

WARREN, E. R. Some Interesting Beaver Dams in Colorado, by Edward R. Warren. Proc. Wash. Acad. Sci. Vol. VI. pp. 429-437. February 28, 1905.

THE MAMMALS OF COLORADO.

Cervus canadensis. ELK. WAPITI.

Formerly abundant over a great portion of the State, except the prairie region. Now they are almost exterminated. W. L. Burnett reports that a few are yet to be found in the western part of Larimer county. There are still some in Routt county, though I have no definite information as to their numbers. In the western part of Gunnison county, and the adjoining portions of Delta, Mesa, Garfield and Pitkin counties, there are but very few left, where once there were many. Dr. E. F. Eldredge of Grand Junction reports some in the Roan Mountains, in Garfield and Rio Blanco counties, and no doubt there are some in other parts of Rio Blanco county, and also in Grand county. State Game Commissioner J. M. Woodard reports a very limited number in Mesa, Mineral and La Plata counties, and in July, 1905, at Wagon Wheel Gap, which is in Mineral county, I was told there were a few in the mountains about there. Very possibly there are a few in other parts of the State from which I have no information.

Odocoileus macrourus. WHITE-TAILED DEER.

Once fairly abundant among brushy creek and river bottoms, among and near the foothills, out onto the plains, and in some parts of the mountains. I have but little information as to its present distribution. A. E. Beardsley says it is becoming scarce in Boulder, Larimer and Weld counties. The Maxwell Collection at Philadelphia in 1876 contained a specimen taken on the Cache la Poudre River. C. E. Aiken says there are a few in the foothills west of Monument, El Paso county, unless recently killed off. Dr. W. H. Bergtold tells me it is still found near Trinidad and southward, and also in parts of the Arkansas Valley, between Pueblo and the State line.

Odocoileus hemionus. BLACK-TAILED DEER. MULE DEER.

Probably has been, if not now found in nearly every county in the State. Their greatest numbers are now in Rio Blanco and Routt counties. I have reports of them in Larimer, Boulder, Weld, Jefferson, Mineral, Mesa, Montrose, Garfield and La Plata counties. I have myself seen them in Gunnison county. There are still quite a number in the Pike's Peak region, in El Paso and Teller counties. I was informed that they were found in the extreme western portion of Baca county, and in Las Animas county. No doubt there are more or less still left in their former haunts all over the State. Mr. C. F. Frey of Crawford believes them to be slightly on the increase in the western part of Gunnison county and adjoining territory.

Antilocapra americana. ANTELOPE. PRONGHORN.

Probably once found everywhere on the plains and in the large parks, now scarce and entirely gone from most places. W. L. Burnett reports a few in the northeast part of Larimer county; F. M. Dille says they are becoming more common in northern Weld and the northeastern counties; H. G. Smith says they were last seen in the City and County of Denver in the late seventies. There are still a few in Routt county. W. P. Ela of Grand Junction states that he never heard of but two or three being killed in Mesa county during a residence there of over twenty years. W. E. Wolfe of Wray, Yuma county, informs me that he has reliable in-

information of two bands in different parts of Yuma county, "but their numbers are slowly increasing, owing to stringent law, and a desire on the part of ranchmen to protect them." In Baca county, in the spring of 1905, the writer heard of several small bands in different parts of the county, and also of a band in the southern part of Prowers county.

Dr. Coues, in his list of the Maxwell Collection, says: "I have nowhere else found antelope so abundant as they were in North Park in the summer of 1876. They were almost continually in view, and thousands must breed in that locality." I fear that nowadays the sight of one even in that thinly settled district is a rare thing.

Ovis canadensis. MOUNTAIN SHEEP. BIGHORN.

Formerly found through all the mountainous parts of the State; now much less common, but seems to be increasing, thanks to the game laws, which prohibit their being killed at any season.

W. L. Burnett reports them rare in Larimer county; F. M. Dille considers them to be increasing in the higher parts of Boulder and Larimer counties; Dr. E. F. Eldredge, W. P. Ela and R. H. Sullivan report them from Mesa county, on the Big Dolores River, and in the Book Cliffs; C. H. Smith, of Coventry, Montrose county, says a band are living in the mountains between Telluride and Ouray. H. G. Smith mentions some near Breckenridge, Summit county. There are quite a number about the Snow Mass Range and parts of the Elk Mountains, and Gunnison and Pitkin counties, and also a band in the mountains about Taylor and Union Parks. Game Commissioner Woodard reports a few in Eagle, Mesa and Mineral, and possibly in La Plata counties. There is a band of five or six about Pike's Peak. C. F. Frey tells me they suffer much from scab in the West Elk Mountains, and that a party told him in 1902, at one place near the head of Sapinero Creek seventy-five head were counted which had died of scab. Domestic sheep have been run in that locality, and the wild sheep doubtless contracted it from them.

Bison bison. BUFFALO. BISON.

The information at hand concerning this species is somewhat conflicting. Hon. J. M. Woodard, the State Fish and Game Commissioner, wrote me under date of November 16, 1904, "from the best information obtainable there are no wild buffalo in Colorado," which would indicate that the last remnant, the "Lost Park Herd," had been exterminated. But this present month (January, 1906,) I was informed by a Mr. Noxson of Colorado Springs, that about eighteen months ago, which would be in the summer of 1904, he saw in the Lost Park district a buffalo running with a herd of cattle, and was told that there was still a small herd left in the park. The time has been too short for additional information to be obtained. Once they were distributed more or less abundantly all over the State, even in the mountains. I have found a skull at nearly 11,000 feet near Irwin, Gunnison county, and seen skulls at various other places in the Elk Mountains.

In February, 1879, Mr. C. E. Aiken mounted the head of the last buffalo bull killed near the Seven Lakes, in the Pike's Peak region. A few cows survived for several years longer. The last one in Baca county was killed near Springfield in 1889. It was a cow heavy with calf.

Sciurus aberti ferreus. }
Sciurus aberti concolor. } ABERT SQUIRREL.

As any information by which the ranges of these subspecies of the Abert Squirrel can be separated is lacking, they will be mentioned together. They are apparently quite generally distributed along the foothill district, but their range seems largely limited to between 7,000 and 8,000 feet altitude. The brown and black phases seem to predominate, and as far as I can learn, at least in the northern half of the state, the gray specimens are nearly all referable to *concolor,* the type of which came from Loveland.

Sciurus fremonti. PINE SQUIRREL. FREMONT SQUIRREL.

More or less common in the spruce zone all through the mountains. About Colorado Springs ranges from the mouths of the Cheyenne Canons to the limit of large timber, or a vertical range of nearly five thousand feet.

Eutamias quadrivittatus. WESTERN CHIPMUNK. "LITTLE CHIPMUNK."

Abundant throughout the mountains and foothills up to timberline. As to how far east it extends on the "Divide" and other parts of the State I have no notes, except that I took one in the extreme western part of Baca county, at the eastern edge of the "Cedars," and it was reported common there. I have seen it out in Gunnison county December first at an altitude of 11,000 feet, and the snow quite deep, and have seen it near Colorado Springs on the twenty-first of the same month. Often called "Little Chipmunk" to distinguish it from *Callospermophilus lateralis*, which is called "Big Chipmunk."

Eutamias hopiensis. HOPI CHIPMUNK.

I found this species quite common at Grand Junction, all my specimens being taken around rocky places. None were seen or taken in brushy localities. I know nothing further as to its range, though presumably it will be found elsewhere in the western and southwestern portions of Colorado.

Callospermophilus lateralis. SAY SPERMOPHILE. MANTLED SPERMOPHILE. "BIG CHIPMUNK."

Common in the mountains and foothills, but does not seem to come out of the hills at all, nor does it range quite as high as *E. quadrivittatus*, at least according to the writer's observations. On the higher mountains it does not go above the limit of heavy timber, while the latter species ranges up through the wind-twisted spruces to above timberline. While it disappears, in the Elk Mountains at least, with the first snowstorms in early October, it comes out in the spring before the snow is gone. I have known it to tunnel through three feet of snow to get to the surface. A specimen taken early in April under such circumstances was very fat. At Crested Butte it had disappeared for the winter before October 8, 1905.

Ammospermophilus leucurus. WHITE-TAILED CHIPMUNK. ANTELOPE SQUIRREL.

It is common in the desert region about Grand Junction, and probably in similar districts in the western part of the State. It is found at least as far east as Delta, and Mr. A. B. Williamson of Paonia tells me he has seen it near Hotchkiss.

Citellus variegatus grammurus. ROCK SQUIRREL.

Somewhat common in rocky places at the lower elevations up to perhaps seven thousand feet or a little more. It is, I think, usually rather wild and shy, and therefore perhaps not seen as often as it might be, but my notes indicate a pretty general distribution over the State within its range of altitude. Mr. W. L. Burnett writes me that he does not think it is found farther north than Rist Canon, four miles north of Fort Collins.

The species was first described by Say, the type being taken by the Long Expedition, on Purgatory Creek, Lat. 37° 32′, Lon. 103° 31′.

Citellus variegatus utah. UTAH ROCK SQUIRREL.

I found this subspecies at Grand Junction; it is very probably the form found in the western part of the State, though at present I have no other data concerning it.

Citellus elegans. WYOMING SPERMOPHILE.

I have not sufficient data by which to outline the distribution of this species in Colorado, but it is probably found in many localities in the northern part of the State. W. L.

Burnett reports a large colony between Livermore and Manhattan, Larimer county. Bailey, in "The Prairie Ground Squirrels of the Mississippi Valley," states that it has been taken at Fish Creek, Larimer county, near the Wyoming line. There is a specimen in the collection of the State Historical and Natural History Society from Wolcott, Eagle county. It probably occurs in the North Park.

Citellus obsoletus. Kennicott Spermophile.

Bailey, in the paper quoted above, records it from Sterling, and in a map of the distribution of the species in the same paper shows it as occurring in the northeast corner of the State south of lat. 40, and west of long. 104, the map being on too small a scale to determine exactly. A. E. Beardsley reports it on the plains near Greeley.

Citellus spilosoma major. Large Spotted Spermophile.

Seems to be irregularly distributed through the southeastern portion of the State, the most northwestern record being a specimen taken at Sand Creek, near Denver, by H. G. Smith. Herman W. Nash writes me it is the common ground squirrel about Pueblo. The writer has taken it at Lamar, and at Manter, Baca county, near the Kansas line. According to my observations it prefers sandy soils.

Citellus tridecemlineatus pallidus. Striped Spermophile. Striped Gopher.

Common on the plains, perhaps the most common ground squirrel of the prairie country. Bailey in the paper previously quoted says the western limits of its range in Colorado are "roughly indicated by Fort Garland, Twin Lakes, South Park and Denver." Specimens from Divide, Teller county, seem darker in color than those taken on the plains about Colorado Springs. In Baca county it is commonly called "Chipmunk." I do not know if it is known by that name elsewhere.

Cynomys ludovicianus. PLAINS PRAIRIE DOG.

Very common everywhere on the plains east of the mountains, and extending into the foothills a short distance, but not known to occur west of the Front and Rampart Ranges. In the more thinly settled parts of the plains region, some of their towns cover very large areas, and about cultivated lands the damage done must be great.

Cynomys gunnisoni. GUNNISON PRAIRIE DOG.

The type locality of this species is Cochetope Pass between Gunnison and Saguache counties. It is found west of the Front and Rampart Ranges, and into the western part of the State, but data is as yet to be obtained to define its exact distribution and that of the following species. The writer has specimens from Wagon Wheel Gap, Mineral county, and from Divide, Teller county. It is the species found in the San Luis Valley and that region.

Cynomys leucurus. WHITE-TAILED PRAIRIE DOG.

Both the Biological Survey and A. E. Beardsley report this species from North Park. The writer has taken it at Grand Junction. Judging from these scanty records the species should be found distributed through the more western and northwestern portions of the State.

Marmota flaviventer. WESTERN WOODCHUCK.

Common in the mountains, living even above timberline. Messrs. A. E. Beardsley and E. B. Andrews both mention them as being on the summit of Long's Peak, 14,271 feet. The lower limit of their range is uncertain, but it is not much below 8,000 feet as a rule, I think, and I doubt if many live as low as that. Personally I have noted them as most abundant from 9,000 feet up. But I think their distribution is largely governed by the suitability of the locality to their needs, for they especially like rocky ground and slide rock, and that is where the most woodchucks are found, and the higher one goes the more common such ground becomes.

Castor canadensis frondator. BEAVER.

Was probably at one time found in every stream in the State in any way suited to its needs, and was nearly exterminated by trappers. From such information as I have received, and from my own observations, it appears to be generally distributed over the State from the east base of the mountains west, and is increasing in numbers, thanks to the strict protective laws. It ranges quite high in the mountains; F. M. Dille writes of a colony at about 10,500 feet. A. E. Beardsley notes them in the Platte river, at least twenty miles east from Greeley, and R. H. Sullivan mentions a colony in the Grand River below Grand Junction.

Mus musculus. HOUSE MOUSE.

Seems to be common everywhere in the settled portions of the State. In some of the newer places it mingles about the houses with the local species of Deer Mice. Around Colorado Springs I have caught it out in the fields and on the plains. In a damp springy place I caught several in traps set in *Microtus* runways, and two miles east of the city one was found in a snug little nest under an old tie beside the Rock Island railroad track, and another trapped not far away.

Mus norvegicus. HOUSE RAT.

Found in Denver, Colorado Springs, and Pueblo, and probably some of the other larger cities and towns. A. E. Beardsley speaks of finding in Greeley twelve years ago, part of one which had been killed by a cat, but has not seen one since. Not known at Grand Junction, though there is a tradition of one which arrived in a box car in the early days of the town, but which was promptly taken in charge by a vigilance committee, with the usual result.

Onychomys leucogaster. GRASSHOPPER MOUSE.

Confined to the plains, where it is quite common, though perhaps not abundant. Found all over the plains district lying east of the foothills. As to the species occurring in other parts of the State, I have no information, and do not know if they are this, or some other.

Onychomys leucogaster pallescens. PALE GRASSHOPPER MOUSE.

The Biological Survey has identified specimens from Baca county as belonging to this form, and specimens from Lamar appear to be the same. Presumably the subspecies inhabiting the southeastern portion of Colorado.

Peromyscus tornillo. TORNILLO DEERMOUSE.

I found this species common at Lamar, in the brushy bottoms along the Arkansas River, and at Springfield, Gaume's ranch and Monon, Baca county. This would indicate a quite general distribution in the southeastern part of the State. The specimens taken in Baca county were mostly found among the sandstone bluffs along the water courses, although a few were taken about some ranch buildings. I did not find it in "the Cedars" in the western part of Baca county, it being replaced there by two other species, as noted beyond.

Peromyscus sonoriensis. SONORA DEERMOUSE.

W. L. Burnett writes me it is the common form in Estes Park. Dr. J. A. Allen records it from Florida, La Plata county. These are the only records I have.

Peromyscus nebracensis. NEBRASKA DEERMOUSE.

Deermice are common everywhere, except on the open bare prairies, but the notes I have are so meagre that the distribution of the different species cannot yet be worked out. W. L. Burnett writes me that this is the common White-footed Mouse of the plains of Larimer county, and the writer has found it everywhere about Colorado Springs, up to 11,500 feet, and also at Divide, Teller county, and at Eastonville, on the Divide between the Platte and Arkansas Rivers.

While it does not seem to be on the level prairie, yet, at least around Colorado Springs, wherever there is a gulch or arroyo, this mouse will be found more or less abundantly. In the foothills they are found indifferently among the rocks on the hillsides or along the streams, and in the woods and timber. I found it at Gaume's ranch in the northwest corner of Baca county.

Peromyscus subarcticus. SUBARCTIC DEERMOUSE.

Just what is the distribution of this species in this State I am unable to say. I have taken it at Crested Butte, Gunnison county, from 9,000 feet up, and on Muddy Creek, in the western part of the same county, at from 7,500 to 8,500 feet; at Wagon Wheel Gap, Mineral county, altitude 9,000 feet; and near Grand Junction, altitude 4,600 feet. At the latter place it was not only found among rocks in company with *P. auripectus* but also on the more open ground, and in the brush along the river bank.

Peromyscus luteus. DEERMOUSE.

Mr. S. Arthur Johnson writes me there are specimens in the Agricultural College collection from Fort Collins.

Peromyscus auripectus. GOLDEN-BREASTED DEERMOUSE.

I found this species common among rocks near Grand Junction. As the type locality is Bluff City, Utah, in the southeast corner of that State, it will no doubt be found in suitable situations through the southwestern part of Colorado.

Peromyscus truei. TRUE DEERMOUSE.

I found it quite abundant in the rocks near Gaume's ranch in the northwest corner of Baca county. As this place is near the eastern border of the rough country called "the Cedars," and which covers parts of Baca, Las Animas, Bent and Otero counties, the species will no doubt be found through much if not all that district. Like other large-eared *Peromyscus*, it lives almost exclusively among rocks.

Peromyscus truei nasutus. NORTHERN TRUE DEERMOUSE.

This species was described by Dr. Allen from a type specimen taken at Estes Park. A. E. Beardsley reports it from Boulder county. The writer has found it quite common about Colorado Springs, both in the foothills and in the bluffs to the north and east of the city. It prefers rocky places, and I have never taken it in gulches on the plains, where *P. nebracensis* is common. In some places among the rocks and bluffs it seems to outnumber the later species. I did not find it at Eastonville, though the ground where I trapped seemed favorable enough for it. I have taken it as high as 8,000 feet.

Reithrodontomys dychei nebracensis. NEBRASKA HARVEST MOUSE.

Dr. Allen's type came from Kennedy, Nebraska; in the description of the species he records specimens from Canon City and Loveland. A. E. Beardsley reports it from Boulder county. These are the only notes at hand.

Reithrodontomys montanus. MOUNTAIN HARVEST MOUSE.

Baird, in his original description of this species, gave the type locality as "collected in the vicinity of the Rocky Mountains, lat. 38 degrees." Dr. J. A. Allen fixes it in the upper part of the San Luis Valley, which is probably as close as can be done with the indefinite information at hand. The type remains unique, no other specimen having yet been taken.

Neotoma floridana baileyi. BAILEY WOOD RAT.

Dr. Allen, in his original description of *N. campestris*, which is a synonym of this species, mentions a specimen from Fort Lyons, on the Arkansas River, collected by Captain P. M. Thorne, U. S. A. Mr. H. W. Nash reports it as common about Pueblo.

Neotoma micropus. BAIRD WOOD RAT.

The writer has taken this species at Monon, Baca county, and it is also found at Springfield. I found it living altogether among rocks, except some taken about an unoccupied ranch, where they were living in the buildings. No houses were found in the open country, such as are described by Bailey in "The Biological Survey of Texas."

Neotoma fallax. GALE WOOD RAT.

The type of this species came from Gold Hill, Boulder county, and was collected by Mr. Denis Gale. W. L. Burnett reports it as common along the foothills in Larimer county, and says that it and *N. cinerea orolestes* occur together. I have taken it near Colorado Springs, both in the foothills and in the sandstone bluffs north of the city. I also found it near Grand Junction, but it was not nearly as abundant as *N. Orolestes.* No doubt it occurs along most of the base of the mountains, but as to its eastern and western range I have absolutely no information, except the above Grand Junction record.

Neotoma albigula. WHITE-THROATED WOOD RAT.

This species I found at Gaume's ranch, in the northwest corner of Baca county, living among the rocks. Like *Peromyscus truei,* it will very likely be found to inhabit most of the cedar country. It did not seem to breed as early as *N. micropus* at Monon, for half-grown young of the latter species were taken the first of May, while the present species was apparently just beginning to breed after the middle of the same month.

Neotoma cinerea orolestes. MOUNTAIN RAT.

The type of this subspecies came from the Saguache Valley, 20 miles west of Saguache. It is common from the eastern foothills apparently to the western border of the State. In the eastern part its range overlaps that of *N. fal-*

lax. As everywhere else, it is apt to be a good deal of a pest about houses and cabins from its mischievous and thievish habit of carrying off any portable articles and hiding them, and it is wonderfully industrious in carrying rubbish into houses which happen to be unoccupied. The writer has seen a double bunk in a miner's cabin filled with leaves, chips, sticks and other trash, by these animals. Sometimes, in common with other species of the genus, called Trade Rats.

The writer has a specimen which has rather a curious history, having lived in a fruit store in Colorado Springs, and becoming so tame as to allow itself to be handled. It was killed by accident, having bitten a boy who handled it a little too roughly, and who threw the rat on the floor rather violently, and killed it.

I found this species abundant among rocks near Grand Junction, much more so than *N. fallax,* and apparently inhabiting a wider range of territory, at least specimens were taken about rocks close to the Gunnison River, and on the hills above, while the specimens of the other species were all taken on the higher ground.

Phenacomys preblei. PREBLE LEMMING MOUSE.

Described by Dr. C. Hart Merriam from a specimen taken on the side of Twin or Lilies Peak, near Long's Peak. No other specimens have been taken since.

Evotomys gapperi galei. COLORADO RED-BACKED MOUSE.

The type of this species came from Ward, Boulder county, and was collected by Mr. Denis Gale, and described by Dr. Merriam. I have taken it at Crested Butte and at Irwin, Gunnison county, at altitudes from 9,300 to nearly 11,000 feet; in the mountains near Colorado Springs, at an altitude of 7,500 feet, and at Lake Moraine, 10,250 feet, and at Divide, 9,200 feet. Elliot gives its distribution as "Mountains of Colorado, north on eastern ranges of Rocky Mountains to northern Montana," and it thus should be found all through the mountainous parts of the State.

Microtus pennsylvanicus modestus. SAGUACHE VOLE.

Baird described this subspecies from a type specimen taken on Cochetope Pass. Bailey (Revision of American Voles of the Genus *Microtus*) notes specimens from the following localities: Fort Garland, Loveland, and Twin Lakes. W. L. Burnett says it is the common vole about Fort Collins. A. E. Beardsley notes it from Boulder county and Estes Park. I have found it near Colorado Springs near the west boundary of the city, and at Divide, Teller county, altitude 9,200 feet. These localities go to show a pretty general distribution over the central part of the State. I have no notes as to the voles of the extreme western portion, except as noted beyond from Grand Junction, nor of the eastern plains portion.

Microtus nanus. DWARF VOLE.

Bailey in his Revision of Microtus says that it occurs in the Canadian Zone, which in Colorado confines it to the mountains. He records specimens from Estes Park, Cochetope Pass, Twin River and Twin Lakes. I have taken it at Crested Butte and Irwin, Gunnison county, the latter locality at 10,700 feet. These records show a range over practically the total width of the mountainous parts of the State, and Bailey says it is found from southern Colorado north.

Microtus mordax. CANTANKEROUS VOLE.

Bailey gives its distribution as "Rocky Mountains and outlying ranges from latitude 60 to northern New Mexico. . . . Common in Canadian and Hudsonian Zones." He notes specimens from Estes Park, Ward, Gold Hill, Long's Peak, Canon City, Lake City, Silverton and Fort Garland. I have it from Crested Butte and Irwin, Gunnison county; Divide, Teller county; Lake Moraine, El Paso county, and one taken on Bear Creek, near Colorado Springs, nearly a mile below the mouth of the canon, at an altitude of about 6,500 feet. I also found it at Wagon Wheel Gap, Mineral county; and near Grand Junction, at an altitude of 4,600 feet.

Microtus austerus haydeni. HAYDEN VOLE.

Bailey gives Eastern Colorado as part of its range, and notes specimens from Loveland and Canon City. These would of course be from its western limit, and as it is found in Kansas, Nebraska and Wyoming it should be found over the whole of the plains region of the State. A. E. Beardsley reports it as common at Greeley. S. Arthur Johnson reports specimens in the Agricultural College collection from Fort Collins, and which the United States Biological Survey states are darker than the typical form.

Fiber zibethicus. MUSKRAT.

This species seems to be common all over the State wherever there are suitable situations for it to live. A nuisance around dams and large ditches from its habit of burrowing in the banks. Some of the ditch companies at Grand Junction and in the Grand Valley pay bounties for killing them.

Geomys lutescens. YELLOW POCKET GOPHER.

This is the common Pocket Gopher of the plains region, ranging from the foothills east to the Kansas line, excepting most of that portion occupied by *Cratogeomys castanops.* I have found it and *Thomomys clusius* together near Colorado Springs, jointly occupying a scope of territory not yet exactly defined. Neither species is found over the whole of this ground, but scattered colonies of each are here and there in suitable places. Along the Rock Island railroad track, about two miles east of the city, I have taken specimens of both species within a hundred yards of each other.

Cratogeomys castanops. CHESTNUT-FACED POCKET GOPHER.

The type of this species came from near the present town of Las Animas, and it ranges south into New Mexico and beyond. According to the map in Merriam's Monograph of the *Geomyidae* it reaches west to about lon. 104° 30′. I have taken it at Monon, Baca county, practically on the

Kansas line, and there it was in company with *G. lutescens.* The two species were also found at Lamar. The Arkansas River seems to be about the northern limit of its range, but I have seen a specimen from near the large reservoirs several miles north of Lamar.

Thomomys clusius. PLAINS POCKET GOPHER.

The writer has found this species quite common on the plains near Colorado Springs, and occurring with *G. lutescens,* as noted under that species. The State Historical and Natural History Society has one in its collection from Estes Park. I have no other data as to its distribution in this State.

Thomomys aureus. GOLDEN POCKET GOPHER.

Dr. Merriam writes me that "A *Thomomys* from Grand Junction appears to be *aureus.*" Dr. F. W. True writes there is a specimen in the National Museum from Los Pinos, La Plata county.

Thomomys fossor. MOUNTAIN POCKET GOPHER.

The type of this species came from Florida, La Plata county. It is probably the common species found through the mountainous parts of the State. W. L. Burnett has taken it at Estes Park; I have taken it at Crested Butte, and on Muddy Creek, in Gunnison county; also at Divide, Teller county.

Perodipus montanus. MOUNTAIN KANGAROO RAT.

The type specimen of this species was taken by Captain Beckwith's Expedition of the Pacific Railroad Surveys, and described by Professor Baird in 1855. It inhabits the San Luis Valley, but I know nothing as to the extent of its range.

Perodipus montanus richardsoni. RICHARDSON KANGAROO RAT.

I have not full data as to the distribution of this form, but it seems to be the species occupying the plains region east of the foothills. It has been reported to me from Denver, Greeley and Jefferson county, and I have taken it at Colorado Springs, Lamar, and in Baca county.

Perognathus fasciatus infraluteus. BUFF-BELLIED POCKET MOUSE.

The type of this species came from Loveland, and I know of no other record of its occurrence in this State, or elsewhere as a matter of fact.

Perognathus flavescens. PLAINS POCKET MOUSE.

According to Osgood (Revision of *Perognathus*) this should be found from the foothills east over the plains. He records it from Boulder county, Greeley, Pueblo and Sterling. I have taken it at Colorado Springs. It is either not common there, or else hard to trap, as I have taken only two specimens, though considerable time has been spent trying for them.

Perognathus flavus. BAIRD POCKET MOUSE.

Osgood gives the distribution of this species as "Upper and Lower Sonoran Zones from northeastern Colorado and western Nebraska to northern Mexico, extending westward into central Arizona and eastward to western Texas." Should apparently be found in the western part of the State as well as the eastern, but the only records I have are eastern. Osgood gives it from Burlington, Canon City, Fort Garland, Greeley and Loveland; A. E. Beardsley from Greeley also, and I have taken it at Colorado Springs, Lamar and at Springfield, Baca county. S. Arthur Johnson reports it from Fort Collins.

Perognathus hispidus paradoxus. KANSAS POCKET MOUSE.

Osgood gives the distribution as "Upper Sonoran Zone of the Great Plains from the Dakotas to Texas, westward to base of Rocky Mountains," thus covering all of Colorado east of the foothills. He gives two records, Boulder county and Sterling. I have taken it at Monon, Baca county.

Zapus hudsonius campestris. PRAIRIE JUMPING MOUSE.

Preble, in his "Revision of Zapus," gives its distribution as "Great Plains from Manitoba southward to Nebraska and westward to Colorado and Wyoming." He records it from Loveland, and A. E. Beardsley reports it from Greeley.

Zapus princeps. ROCKY MOUNTAIN JUMPING MOUSE.

The type came from Florida, La Plata county, and was described by Dr. J. A. Allen. Preble records it from Cochetope Pass, Florida, Fort Garland, Gold Hill, Rocky Mountains (39.) Dr. F. W. True writes me the National Museum has specimens from Black Hawk and Boulder. I have taken it at Crested Butte, and seen one near the head of Thompson Creek, in the extreme western part of Gunnison county. As shown by the above records, it is distributed over the whole of the mountainous parts of the State, but I doubt if it is abundant anywhere.

Erethizon epixanthus. YELLOW-HAIRED PORCUPINE.

Found all through the timbered parts of the State, but most plentiful, naturally, in the mountains, where they range to the edge of timberline. I have seen them among the dwarfed trees at that altitude. It has been found to some extent at least, along the wooded river and creek valleys outside the mountains. In spite of its protecting quills, it is eaten by coyotes, mountain lions, and bobcats, though possibly only in winter when other food is scarce, that being the only season when the writer has found remains of the animal so killed.

Ochotona saxatilis. CONY. PIKA.

Found all through the mountainous parts of the State, usually living among the slide rock near timberline, ranging both above and below that altitude. The lowest I can recall having seen it is about 9,300 feet, near Crested Butte, this on a rock slide low down on the mountain. It is usually rather abundant wherever found, though the animals always seem to live alone, not even in pairs. Their hay piles are noticeable features of the rock slides where they live, but I fear they do not always provide a sufficiency, for sometimes after unusually hard winters in Gunnison county, I have noticed the conies were scarce for a year or two.

Lepus americanus bairdi. SNOWSHOE RABBIT.

Found in all the higher portions of the State, through the mountains, but probably not ranging much, if any, below 9,000 feet. It seems to vary much in abundance, as it is reported plentiful in some places, and rare in others. At a recent visit to Lake Moraine, El Paso county, I could hear nothing of it from men who had spent several years there and at the Strickler Tunnel looking after the Colorado Springs water system, though the Mountain Cottontail (*L. pinetis*) is found very high there.

Lepus campestris. WHITE-TAILED JACK RABBIT.

This Jack Rabbit is found over nearly all the State except the extreme southeastern part, and the higher mountains. It ranges to about 9,000 feet in Gunnison county. In the mountains it is the only Jack Rabbit found, on the plains it mingles in varying proportions with the Black-tail, the White-tails being most numerous in the north. W. E. Wolfe of Wray, Yuma county, writes they are perhaps the most numerous species there, and prefer the farmed country and meadows adjoining, while the sandhills grass country seems to be the favorite haunt of the Black-tail.

Both species often become great pests in cultivated districts and the Lamar Rabbit Hunt was for several years a regular event, excursions being run on the railroad, and thousands of rabbits were killed each year, most of which went to the poor of Denver and Pueblo, being distributed under the direction of Rev. Thomas A. Uzzel. These hunts were gotten up expressly for the purpose of at least partly exterminating the rabbits. None have been held for several years. Most of the Lamar animals are Black-tails. Mr. J. M. Johnston of Monon, Baca county, told me that when he first settled there there were a few White-tails, but there are none now. That was about fifteen years ago.

Lepus arizonæ. ARIZONA COTTON-TAIL.

This is the Cotton-tail Rabbit about Grand Junction, and it is no doubt the species found in the lower portions of the western and southwestern parts of the State, though specimens are at present lacking by which to map its range.

Lepus arizonæ baileyi. BAILEY COTTON-TAIL.

This subspecies seems to be the Cotton-tail inhabiting the plains in that part of Colorado east of the foothills, though the rabbits of that portion have not yet been sufficiently studied to state definitely if it occupies the entire district. W. L. Burnett has taken it at Spring Canon, Larimer county; the collection of the State Historical and Natural History Society has a specimen from Denver; the writer has taken it at Colorado Springs. As it also occurs in southwestern Wyoming, it should also be found in northwestern Colorado, in the dryer, more arid portions. I found this species at Monon, in the eastern part of Baca county, practically on the Kansas line, and at Gaume's ranch, in the northwest corner of the same county.

Lepus pinetis. MOUNTAIN COTTON-TAIL.

From present data this seems to be the Cotton-tail inhabiting the higher range of this form of rabbit. The records at hand indicate a pretty general distribution about the mountainous and western parts of Colorado, W. L. Burnett reporting it from Estes Park, while the writer has specimens from Lake Moraine, El Paso county; Crawford, Delta county; Coventry, Montrose county; Mancos, Glenwood Springs and Meeker, making a range in altitude from 6,000 to above

10,000 feet. Much of course remains to fully work out its distribution.

The various forms of cottontails are usually fairly plenty wherever found, depending of course on the amount of hunting, at least on that than on any other cause, for man does more to thin out any species than any predaceous animals. The habits of the cotton-tails are about alike, they all preferring rocky or brushy places to the open country.

Lepus texianus melanotis. BLACK-TAILED JACK RABBIT.

Found over the entire plains region from the foothills east. I have reports of a Black-tail Jack from the western part of the State, but have seen no specimens and do not know if it is this form or some other. W. L. Burnett reports it rare in Larimer county; A. E. Beardsley and H. G. Smith report is as common near Greeley and Denver respectively. It is perhaps the more common form about Colorado Springs. See *ante* under *L. campestris* for comparison of ranges and relative abundance.

Felis hippolestes. MOUNTAIN LION. COUGAR.

Probably found more or less all over the State, but now most abundant in the western portion, particularly in Routt and Rio Blanco counties. Steve Elkins, of Mancos, thinks they are increasing in that locality. It is quite possible they may be increasing in other districts, where they are not much hunted, and there is game or cattle for them to prey on. They are reported as particularly destructive to young colts. President Roosevelt, in his hunt in Rio Blanco county, in the early part of 1901, secured the finest series of specimens of this species ever brought together, with much information as to size, weights and habits. His largest, a male, measured eight feet from nose to tip of tail, and weighed 225 pounds.

Lynx canadensis. CANADA LYNX.

Reliable information concerning this species is much to be desired. It no doubt occurs in the higher more heavily timber mountains, but many, if not most of the reported lynxes are the big mountain bobcat, *L. uinta*. C. E. Aiken had a skin in his store from Beulah, Pueblo county, and which was taken either in the Greenhorn or Sangre de Christo range.

Lynx baileyi. BOBCAT. WILDCAT.

This is probably the bobcat of the lower portions of the State, but reliable information seems to be lacking concerning it. The writer has one taken in the northwestern part of Baca county. Bobcats of some species are found all over the State, and in some places they are quite common, and destructive to poultry. But they, in common with coyotes and foxes, must pick up a great many mice, wood rats and rabbits, and so long as they leave the chickens alone, are really beneficial animals.

Lynx uinta. MOUNTAIN BOBCAT.

Dr. Merriam, in his original description of this species, says that in Colorado and Utah it is restricted to the mountains. The skulls of two specimens, one from Gillette, Teller county, the other from Crystal Park, in the mountains near Colorado Springs, were both identified by the Biological Survey as belonging to this species.

Canis nubilus. GRAY WOLF.

Probably found over most of the State, both on the plains and in the mountains, though apparently nowhere common, and often rare. I have seen one as high as 9,800 feet in Gunnison county. Cattlemen and others are rather persistent in their attempts to exterminate them, but so long as there are such large thinly settled areas on the plains, the wolves will continue to exist in some numbers.

Canis nebracensis.
" **lestes.**
" **mearnsi.** } COYOTE.
" **estor.**

Common all over the State, being represented by these four species or subspecies whose distribution and relationships are not yet well worked out. Dr. C. Hart Merriam writes me that "the common species of the plains is *C. nebracensis.* The small desert species which enters the southwest corner of Colorado in the San Juan region is *estor.* Besides these both *C. lestes* and *mearnsi* appear to occur. *C. lestes* appears to range along the foothills of the Rocky Mountains, but I know nothing of the range of *mearnsi,* except from the two skulls you have just sent" (Skulls came from Crested Butte.)

The coyotes hold their own well against civilization and seem to be just as abundant now as they ever were, in spite of a more or less persistent warfare which is waged against them. If they would leave poultry, young calves, sheep and chickens alone, they would probably do more good than harm as they destroy great numbers of mice and such small animals. On a sandy mesa south of Lamar the writer found many coyote droppings which were composed largely of the skulls and other bones of kangaroo rats.

Vulpes macrourus. RED FOX.

This fox is probably confined to the mountains, and in many places is fairly common. Mr. C. E. Aiken thinks it is not found much below 8,000 feet. It exhibits the usual color phases of the red foxes; of six specimens taken at one place near Crested Butte, four were cross foxes, and two red.

Vulpes velox. SWIFT.

More or less common on the plains and desert regions of both the eastern and western portions of the State.

Urocyon cinereo-argenteus. GRAY FOX

Apparently found through much of the State, but preferring a lower altitude to the red fox, and thus supplementing its range by occupying areas from which the other is absent. Lack of specimens have prevented the determination of the subspecies to which our form belongs.

Ursus horribilis horriæus. SONORAN GRIZZLY.

The distribution of this subspecies of the Grizzly Bear is given as "Colorado and southern Utah, through New Mexico and Arizona to southern California." (Elliot.) One often hears of Grizzly Bears being killed in this State, but they almost always turn out to be some form of the Black Bear. Material to determine the occurrence and distribution of the Grizzly in Colorado seems absolutely wanting.

Ursus americanus. BLACK BEAR.

Found through all the State where there is suitable country. Common in many places, and since the bounty for their scalps was abolished several years ago has increased in numbers in some localities. As a rule, I do not think the bears do much harm. Once in a while one acquires a taste for beef and becomes notorious through a certain district as a cattle killer. If sportsmen and hunters would take pains to preserve unmutilated the skulls of such bears as they kill, with data as to locality and sex, we would soon be in possession of information as to the species.

Bassariscus astutus. RING-TAILED CAT. CIVET CAT.

A. E. Beardsley writes me, "I have seen a living specimen and several skins from near Delta, Colo., and feel certain that it may be found throughout southwestern Colorado, as it has been clearly described to me by residents of Durango and the San Luis Valley and appears to be well known throughout that region." H. G. Smith also says it is reported from southwestern Colorado. In June, 1905, C. E. Aiken mounted the skin of one taken near Grand Junction. He also tells me that a ranchman described to him an animal seen in Beaver Park, in Fremont county, which could have been no other than this species. The writer made inquiries in Baca county, but could hear nothing of it. The only evidence obtained was from a man who had seen an animal that seems to have been this in Oklahoma, but a few miles south of the Colorado line.

Procyon lotor. RACCOON.

Found east of the foothills in varying abundance; my correspondents north of the divide speaking of it as quite common, while Mr. C. E. Aiken considers it very rare about Colorado Springs. The writer has never seen it. I have no reports of it in the western part of the State. It seems to most commonly be found in the timber along the streams. Material has been lacking to determine the subspecies occurring in the State.

Taxidea taxus. BADGER.

Found more or less abundantly all over the State, both on the plains and in the mountains, ranging as high as timberline, if not living there permanently. I have a specimen which I killed in Gunnison county at an altitude of about 11,500 feet. Except when it attacks poultry, it is without doubt a beneficial animal. It eats many mice and rats, digs out prairie dogs and other burrowing animals, in fact really the worst things that can be brought against it are the holes it digs everywhere it goes, and which have proved pitfalls for many a horseman.

Mephitis mephitis hudsonica. NORTHERN PLAINS SKUNK.

While skunks are common all over the State, I do not think the distribution of the species has been worked out to any great extent, and in many places this and the following species occur together, but apparently this is more common on the plains than in the mountains. W. L. Burnett says it is the common skunk in Larimer county, and other correspondents also report it from the plains, but I am not sure if they always distinguish the two kinds. Howell, in his "Revision of the Skunks," records it from Arkins, Larimer county, only.

Mephitis mesomelas varians. LONG-TAILED TEXAS SKUNK.

Howell, in his "Revision," gives records from the following localities: Arkins; Chivington, Kiowa county;

Cañon City; Boulder county; Costilla county; Cotopaxi, Fremont county; and Loveland. A specimen taken by the writer at Crested Butte was identified by the Biological Survey as this species, but not quite typical. The skull only was examined, however. I have also taken it in Baca county. Like many other carnivorous mammals, just as long as they leave domestic animals alone, they are undoubtedly beneficial, for innumerable grasshoppers, to say nothing of mice and such small animals are eaten by skunks. The droppings left by skunks in the summer are often composed of nothing but the bones and other hard parts of grasshoppers.

Spilogale tenuis. SPOTTED SKUNK.

This species was described by Arthur H. Howell from a type specimen taken at Arkins, Larimer county, by R. S. Weldon. Mr. Howell says in his paper describing the species, "it is apparently a mountain animal but is at present known from only two localities—Arkins and Estes Park, Colorado." Spotted skunks seem to be known all over the State, that is the lower portions, but I have no other records than this which give the species. *S. interrupta* very likely occurs in the plains region of the eastern portion, and I have been told of a spotted skunk about Grand Junction, and that is probably some other form.

Gulo luscus. WOLVERENE.

Found only in the higher, mountainous parts of the State, and apparently rare there. I have no actual records of the animal having been taken of late years. Mr. E. L. Chesnut, of Irwin, Gunnison county, writes me that he caught one near that place about 1890. He also trapped one a few years previously. In October, 1905, the writer saw fresh tracks of one in the snow near that place, at an elevation of nearly 11,000 feet. In "The Big Game of North America," an article on the Wolverene, by C. A. Cooper, mentions four adults being taken at Trapper's Lake, Garfield county, in the winter of 1889, and Mr. Cooper also states that he killed one "while crossing the mountains between Middle and Egeria Parks, Colorado," in the winter of 1883.

Mustela americana. PINE MARTEN.

Found in greater or less abundance through the mountainous portions of the State, being thinned out by trapping in some parts, and in others molested but little or not at all. It frequents the heavy spruce timber almost exclusively.

Mustela caurina origenes. ROCKY MOUNTAIN MARTEN.

S. N. Rhoads described this subspecies in his "Synopsis of the American Martens" from a specimen taken by Ernest Thompson Seton at Marvine Mountain, Garfield county (?). Mr. Rhoads also includes Colorado in the range of *M. americana.* The writer is a little skeptical as to there being two species of marten in the State, but the lack of specimens prevents the settlement of that point at present.

Lutreola lutreocephala energumenos. MINK.

Probably found on almost every stream of any size in the State, though of course in varying numbers, depending on the food supply, and on the amount of trapping that is done. A specimen from near Colorado Springs, belonging to C. E. Aiken, and one from Crested Butte, in the writer's collection, were both identified as belonging to this subspecies by the Biological Survey, as also was one belonging to W. L. Burnett, and taken near Fort Collins. Judging from Colorado skins Mr. Aiken has shown me, there is much variation in the quality of the fur in skins from different districts, even when taken at the same season.

Putorius nigripes. BLACK-FOOTED FERRET.

Apparently distributed over all the plains region east of the mountains, especially frequenting the prairie dog towns, the inhabitants form a large part of its food. But I have some specimens and records which indicate both a greater western range and a greater vertical one than has usually been attributed to it. One specimen in my collection came from Divide, Teller county, at an elevation of 9,800 feet, another was found dead in Lake Moraine, El Paso county, altitude 10,250 feet. It is a mystery how the animal came there, as when skinned there were no marks on its body to indicate the cause of death. In the spring of 1904 C. E. Aiken mounted one which came from near Clyde Station, El Paso county, altitude 9,440 feet. Judging from the Divide record, it may yet be found in South Park.

Putorius streatori leptus. DWARF WEASEL.

Dr. C. Hart Merriam described this subspecies from a type specimen taken at Silverton, San Juan county. W. L. Burnett reports it from Larimer county, but rare. The writer has taken it at Crested Butte. An inhabitant of the higher elevations and no doubt found all through the mountainous parts of the State. About Crested Butte, judging from the tracks one sees after a fresh fall of snow, it is quite common. It often burrows under the surface of the light snow, and runs beneath for quite a distance, then reappears on top, having been hunting down a mouse.

Putorius longicauda. LONG-TAILED WEASEL.

Apparently found over most of the plains region east of the foothills. A. E. Beardsley says it is common on the Platte river and about Greeley, and thence to the foothills. The State Historical and Natural History Society has one in its collection from Wray, Yuma county. I could hear nothing of any weasels in Baca county, though the Black-footed Ferret is well known there.

Putorius arizonensis. MOUNTAIN WEASEL.

This species represents the preceding in the higher parts of Colorado, though definite information as to its distribution is wanted. W. L. Burnett says it is the common weasel about Fort Collins, and C. H. Smith reports it as quite common at Coventry, Montrose county. At Crested Butte the writer has heard of but one, and that was killed by some friends of his in the summer of 1905. Parties trapping marten in that country have only mentioned the small weasel as troubling them by getting into the marten traps. I have one taken in a trap set for a Pocket Gopher beside the Rock Island railroad track, two miles east of the city.

Lutra canadensis. OTTER.

My notes on this species are rather unsatisfactory, in fact the only records I have are as follows,—Dr. E. F. Eldredge of Grand Junction reports a few in that vicinity, and also on the Big Dolores River; A. E. Beardsley reports one specimen from the Platte River east of Greeley, and H. G. Smith says it is occasional near Julesburg. It is somewhat difficult to account for its apparent rarity, unless the absence of sufficient water in the streams all the year round. Many of our mountain streams which have a very large flow in spring and early summer dwindle to almost nothing in midwinter, from the freezing of their sources of supply. This would of course keep the otters away, and is really the only reason that occurs to the writer. Certainly it cannot be the cold climate of the mountains, for that is no worse nor as bad as that of more northern latitudes where the animal lives the year round. It is possible our otters may be a different subspecies from that which I have called it, but there is no material to determine if such is the case.

Sorex personatus. SHREW.

Two specimens from Irwin, Gunnison county, taken at an altitude of 10,700 feet, were identified by Dr. Merriam as this species. My only Colorado record.

Sorex personatus haydeni. HAYDEN SHREW.

The writer has a specimen which has been identified by Dr. Merriam as this species, and which was taken at Lake

Moraine, El Paso county, altitude 10,250 feet. It is the only record I know of from the State.

Sorex vagrans dobsoni. DOBSON SHREW.

I have one taken at Lake Moraine, and identified by Dr. Merriam. As in the case of the preceding species, it is the only Colorado record I have.

Sorex obscurus. OBSCURE SHREW.

Dr. Merriam, in his "Synopsis of the American Shrews of the Genus Sorex," states that it is restricted to the Boreal Zone. He records it from Long's Peak; Boulder county; Fort Garland; Cochetope Pass, and Silverton. Dr. F. W. True reports specimens in the National Museum from Black Hawk, Gilpin county; Boulder and Nederland, Boulder county. The writer has taken it at Crested Butte, Gunnison county, and at Lake Moraine and Strickler Tunnel, El Paso county, the latter point at an elevation of 11,600 feet; also on a tributary of Bear Creek, near Colorado Springs, altitude about 7,000 feet. They seem to be quite common where found, though not often seen, indeed their movements through the grass and brush are so quick that it is hard to get more than the merest glimpse of them.

Sorex tenellus nanus. DWARF SHREW.

Dr. Merriam described this subspecies from a type taken at Estes Park, and also records another specimen from Westcliff, Custer county. I have one taken on Bear Creek, near Colorado Springs.

Neosorex palustris navigator. WATER SHREW.

Seems to be generally distributed through the mountains. Merriam records it from Gold Hill, and Cochetope Pass; the National Museum has specimens from Boulder and Black Hawk; I have it from Crested Butte, and found it quite common at Lake Moraine.

Corynorhinus macrotis pallescens. BIG-EARED BAT.

Miller in his "Revision of the Vespertilionidæ," says: "Probably throughout the Austral zones from California, Colorado . . ." He notes a specimen from Larimer county, and A. E. Beardsley two from Trinidad. S. Arthur Johnson reports one in the Agricultural College collection from Fort Collins.

Myotis lucifugus longicrus. LITTLE BROWN BAT.

Miller gives its distribution as "Boreal and Transition zones from Puget Sound east to Wyoming; south at least to Arizona . . ." The only Colorado record he gives is Grand Junction.

Myotis californicus. CALIFORNIA BAT.

Miller gives the distribution of this species as "Austral zones and lower part of Transition zone throughout the western United States and lower California, east to Wyoming and Texas," which would include Colorado, but he gives no records and I have not received any; in fact, my information as to our bats is scanty indeed, and I would be very glad to hear of any specimens of any of the species.

Myotis subulatus. SAY'S BAT.

The type locality of this species is the Arkansas River, near La Junta, Colorado, and the species was described by Say from a type specimen taken by the Long Expedition. Miller gives no records from the State; the writer has seen two specimens taken at or near Colorado Springs.

Myotis evotis. LONG-EARED BAT.

Miller gives the distribution as "Austral and Transition zones from the Pacific Coast to the eastern edge of the Rocky Mountains; south to Vera Cruz." He notes specimens from Loveland.

Lasionycteris noctivagans. SILVER-HAIRED BAT.

Miller gives distribution as "North America from Atlantic to Pacific," and notes a specimen from Rifle, Garfield county, while A. E. Beardsley writes that several were taken at Greeley. Dr. J. A. Allen records two specimens from Florida, La Plata county.

Pipistrellus hesperus. WESTERN BAT.

Miller gives distribution as "Lower Austral zone in the western United States from western Texas to the Pacific Coast. Limits not known." Specimens noted from Grand Junction.

Vespertilio fuscus. BROWN BAT.

Distribution, "Austral, Transition, and (lower edge of) Boreal zones throughout the United States. . ." (Miller.) Specimens recorded by him from Loveland, and A. E. Beardsley reports it as common at Greeley. Dr. J. A. Allen records one from Florida, La Plata county.

Lasiurus borealis. RED BAT.

Miller says "The typical form of *Lasiurus borealis* ranges through the Boreal, Transition, and Austral zones in eastern North America from Canada to Florida and Texas, west at least to Indian Territory and Colorado." A. E. Beardsley says it is rather rare at Greeley.

Lasiurus cinereus. HOARY BAT.

"Boreal North America from Atlantic to Pacific," Miller, who notes specimens from Larimer county, while A. E. Beardsley says "frequent at Greeley." Dr. S. M. Bradbury has one taken at Grand Junction. Dr. C. Hart Merriam considers this an important record.

Nyctinomops depressus. BAT.

Dr. S. M. Bradbury has one taken at Grand Junction, and which has been identified by Mr. Gerrit S. Miller, Jr. It seems to be a very interesting record, as apparently but few specimens of the species are known.

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COLORADO COLLEGE PUBLICATION

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SEMI-ANNUAL BULLETIN

of the

Colorado College Observatory

Containing the

ANNUAL METEOROLOGICAL SUMMARY FOR 1905

F. H. LOUD, PH. D., *Director*

COLORADO SPRINGS, COLORADO
JUNE, 1906

Published by authority of the Board of Trustees of Colorado College every six weeks during the Academic year.

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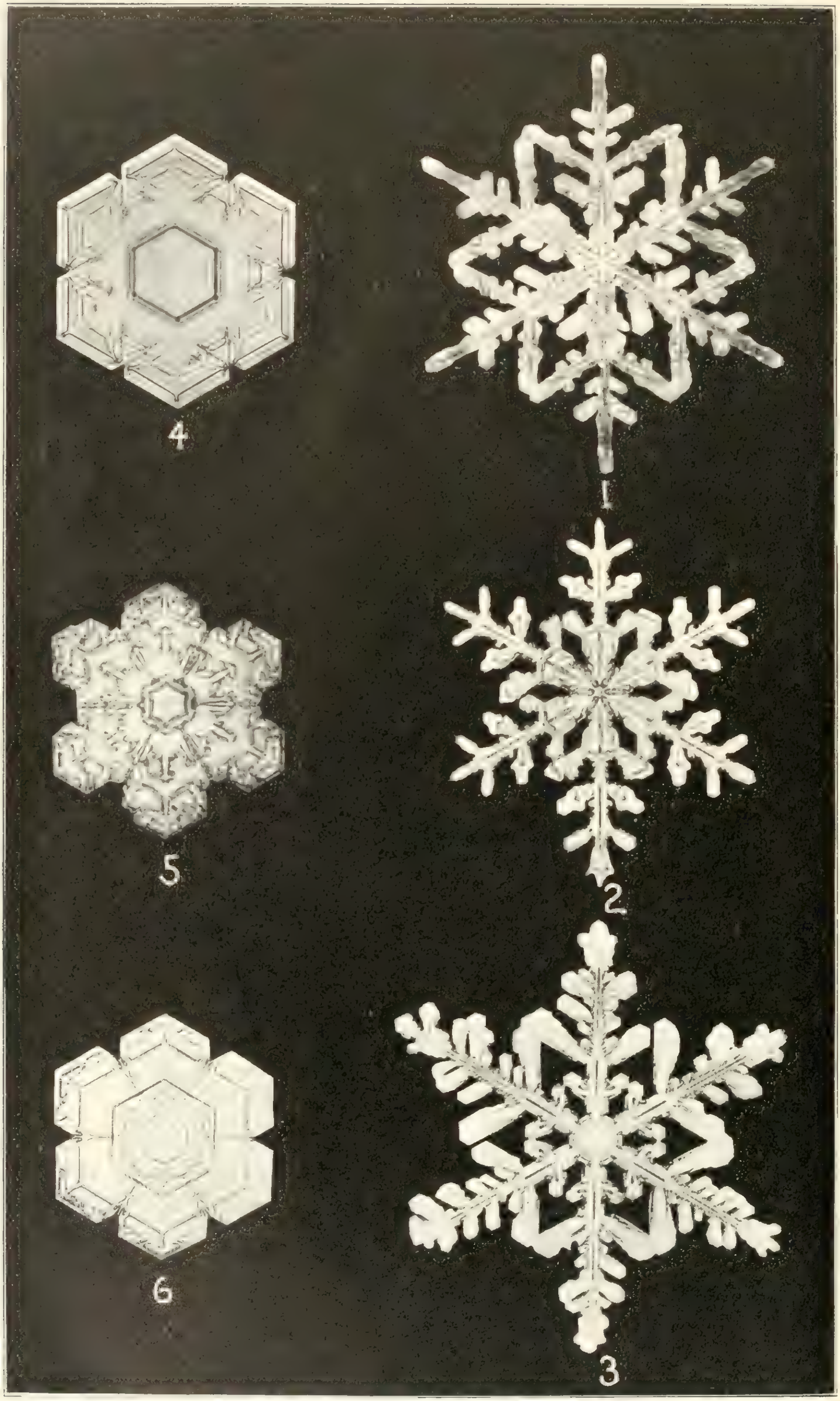
SCIENCE SERIES.

(*Continued on inside of back cover.*)



SNOW CRYSTALS. (Photographs by Bentley.)

Figs. 1, 2, 3. March 13, 14. See page 51.
Figs. 3, 4, 5. March 15. See page 51.

METEOROLOGICAL STATISTICS FOR 1905.*

F. H. LOUD.

BUILDING EQUIPMENT AND EXPOSURE OF INSTRUMENTS.

The Observatory building of Colorado College, erected in 1894, the gift of Henry R. Wolcott, Esq., of Denver, is in latitude 38 deg. 50 min. 44 sec., longitude 6 hr. 59 min. 16.5 sec., elevation about 6,040 feet. (All of these figures are obtained by reference to neighboring stations of U. S. surveys.)

The astronomical equipment consists of a four-inch equatorial telescope, given to the College by the donor of the building, and a transit instrument and clock, given in 1900 by Mr. Charles S. Blackman, of Montreal, Canada.

The meteorological equipment in part antedates the building, the nucleus having been obtained from the U. S. Signal Service when the College first became a voluntary weather station in 1878. Several additions of apparatus were subsequently made. Much the most noteworthy, during the earlier years, was that of a set of Draper self-recording instruments, due to the generous interest of Dr. S. E. Solly, of Colorado Springs. Of these, the barograph alone remains in use. In November, 1903, the quadruple register with all the apparatus connected with it, together

*The matter introductory to the tabulated statistics, presented under this head, is in the main reprinted from the Colorado College Publication (General Series No. 16) which appeared in April, 1905. Readers desiring a more detailed account than is here given, of the process of preparing the Daily Record sheets from the instrumental data, are referred to that issue. A popular description of the instruments, containing some account of the principles of their construction, is to be found in the number for October, 1904.

with a number of other instruments, especially hygrometers of different kinds, were given by General W. J. Palmer, who also provided funds for computation and publication.

The exposure of instruments pertaining to wind, sunshine and temperature is on the roof of Hagerman Hall, a building standing east of the Observatory, and on higher ground. Here is the standard thermometer shelter, 10 feet above the roof, 54 feet above the ground, and 69.5 feet above the level of the Observatory floor. It contains maximum and minimum thermometers, a whirling psychrometer, and a Richard thermograph. Higher by 7 feet, and at horizontal distances of 11 feet from the shelter and 341 feet from the Observatory door, is the wind vane, on the iron support of which are attached the Robinson anemometer and the electric sunshine recorder. The cable connecting these three instruments with the quadruple register in the Observatory is laid underground.

Near the middle of the flat roof of the Observatory, which affords, on the east side of the dome, a clear space 37 feet long (east and west), and $28\frac{1}{2}$ feet broad, and is 16 feet above the ground, is the rain-gauge, provided with a tipping-bucket attachment for registration. It is electrically connected with the quadruple register, which is in the same building, on the first floor. Here, also, on the north side, is a window-shelter for the exposure of the hygrometric apparatus, exclusive of the whirled psychrometer. This consists of a Richard registering psychrometer, a dew-point apparatus, and a hair hygrometer. The Draper barograph is on the south wall of the same room, but the barometer read at the tri-daily observations is in the upper story of Hagerman Hall, at an elevation exceeding that of the barograph by 43.2 feet.

THE DAILY RECORD AND MONTHLY SUMMARY.

From the automatic registers of the different instruments for each day, together with the tri-daily eye observations,—which, being simultaneous with those of the national weather service, occur at 6 A. M., 12 M. and 6 P. M., mountain time,— a sheet called the "Daily Record" is made up. This contains, first, the register of wind. Here the number of minutes in each hour in which the anemoscope indicates the four cardinal points severally is set down, and is followed by a trigonometric reduction, showing the mean hourly bearing of the wind. This is followed by the count of miles, from the anemometer, or the hourly wind-velocity. Succeeding columns exhibit the resolution of this velocity into components along the meridian, and at right angles thereto, as determined by the bearing.

After the wind-record come the two other data derived from the Quadruple Register—viz., the hourly rainfall and sunshine—and after these the pressure as recorded by the Draper barograph at the end of the hour. The temperature, which is next recorded, is obtained from the Richard thermograph, by noting the highest and lowest indications for each hour and taking the half-sum of these as the mean hourly temperature. The humidity records and those on the state of the sky, whether "clear," "partly cloudy" or "cloudy," are taken from the tri-daily eye-observations.

When the ordinary source of information for any of the foregoing data is, for any reason, unavailable, recourse is had to others. For instance, in the rare cases in which the Draper record of pressure is interrupted, the Richard barograph is employed. The sunshine record is supplemented by the indications of a photographic instrument, of a design originating at the Harvard College Observatory, and belonging to the station of the Western Association for

Stellar Photography, about two miles east of the College grounds.

The "Monthly Summary of Instrumental Record," pages 6 to 29, is in the main made up from the sums and means of the "Daily Record." The first column, "Mean Temperature for Twenty-four Hours," is the mean of the column headed "Dry" in the thermometric division of the daily sheet. The "Extremes" are the readings of the maximum and minimum thermometers, and are hence independent of the thermograph, whose indications will, of course, frequently fall short of the limits of range. The "Hours of Extremes," on the other hand, are taken from the Richard instrument. The columns under "Psychrometer" are copies, those under "Clouds at Observation" are sums, from the like columns in the foregoing sheets, hence the scale of cloudiness is here from 0 to 30. The "Number of Minutes Actual Sunshine" is another instance of summation. The "Possible Sunshine," in the next column, is the length of time the sun remains in sight each day, as determined, with careful allowance for the effect of the mountains in the west, in an article in "Colorado Weather," reprinted in the Publication for October, 1904. The ratio of the "actual" to the "possible" sunshine is shown in the column of "Percentage," where the numbers are lower than if the unrecorded morning sunshine were supplied by estimate, as is usual at certain other stations.

The column headed "Barometer, Actual Pressure at 12 M.," is from the eye observation at noon. The "Total Velocity of Wind" is from the sum of the hourly numbers in the Daily Record, checked by the dial-readings of the anemometer. Under the "Sum of Components" are given the footings of the four columns headed "Velocity Resolved" in the Daily Record. From these are deduced trigonometrically the "Equivalent" in direction and number of miles of resultant movement. Finally, under "Rain Gauge" are given the times of ending of the hours during which the first and last precipitation occurred, together with the total amount.

An annual summary by months is appended, page 30.

The care of the instruments and the regular tri-daily observations is committed to two student observers. These, for the year 1905, were Messrs. C. M. Angell and James H. Finger. In the reduction of observations, the director has again enjoyed the benefit of the scrupulous accuracy of Mr. Chas. D. Child.

MONTHLY SUMMARY OF

JANUARY,

DATE.	THERMOMETERS.					PSYCHROMETER.						SUNSHINE RECORD'			
	TEMPERATURES.			Hours of Extremes.		Relative Humidity.			Dew-point.			Clouds at Observ'n.	Number of Minutes.		
	Mean of 24 h.	Extremes. Max.	Min.	Max.	Min.	6 A.M.	12 M.	6 P.M.	6 A.M.	12 M.	6 P.M.		Actual.	Possible.	Per ct.
1	31.0	40	19	4 a.m.	12 n't	63	91	79	22	31	22	25	0	529	0
2	25.7	47	10	3 p.m.	7 a.m.	67	11	64	6	-4	23	0	470	529	89
3	41.2	58	25	3 p.m.	1 a.m.	41	23	21	15	20	9	7	518	530	98
4	35.2	48	24	3 a.m.	12 n't	21	14	34	8	-10	7	2	377	530	71
5	24.0	35	13	3 p.m.	7 a.m.	85	34	32	13	7	6	9	507	532	9
6	21.6	35	11	2 p.m.	6 a.m.	82	31	43	10	8	6	9	469	532	88
7	14.8	20	10	2 p.m.	9 p.m	77	52	36	9	2	4	24	285	533	5
8	25.0	43	9	3 p.m.	3 a.m.	80	43	79	10	16	24	2	373	533	70
9	18.2	23	13	5 p.m.	11 p.m.	85	56	48	14	5	5	27	317	535	59
10	16.8	24	10	2 p.m.	12 n't	86	65	69	15	15	7	30	0	535	0
11	.....	.....	.....	....	....	73	82	53	0	8	7	19	420	536	78
12	.....	.....	.....	....	....	71	65	71	6	5	6	10	172	536	32
13	11.4	29	-7	12 m.	1 a.m.	71	35	51	6	0	2	10	308	538	57
14	16.8	27	8	6 a.m.	10 p.m.	49	10	65	13	-22	3	1	438	539	81
15	29.6	47	9	1 p.m.	1 a.m.	72	31	49	12	20	22	10	431	541	80
16	31.3	41	21	3 p.m.	3 a.m.	77	49	60	18	22	24	18	208	541	38
17	37.2	44	32	10 a.m.	7 p.m.	77	71	83	32	31	31	21	35	543	6
18	34.2	44	25	4 p.m.	12 n't	82	64	81	28	29	26	14	422	544	78
19	33.1	45	21	3 p.m.	5 a.m.	88	43	37	19	23	14	0	514	546	9
20	37.0	45	23	2 p.m.	11 p.m.	21	25	39	6	12	13	2	520	548	9
21	31.5	45	19	3 p.m.	4 a.m.	75	29	59	17	14	23	3	482	551	8
22	35.5	48	20	1 p.m.	5 a.m.	53	32	26	18	18	9	1	483	551	8
23	42.3	52	30	4 p.m.	1 a.m.	33	28	24	13	16	16	2	550	553	9
24	28.8	46	18	4 p.m.	9 a.m.	43	94	61	16	23	20	6	290	555	5
25	......	.....	17	....	12 n't	87	100	88	18	22	20	30	0	557	
26	34.9	54	13	3 p.m.	1 a.m.	57	20	46	15	16	24	11	441	558	7
27	36.0	54	21	4 p.m.	7 a.m.	75	23	40	17	14	21	2	512	560	9
28	33.9	49	21	1 p.m.	12 n't	39	19	61	13	9	25	11	499	562	8
29	22.1	34	17	11a .m.	12 n't	86	89	86	16	26	15	21	298	564	5
30	26.1	46	16	1 p.m.	7 a.m.	86	44	48	15	25	11	11	507	566	9
31	18.0	31	9	2 p.m.	12 n't	86	48	35	16	11	14	27	298	568	5
Sums,	793.2	1154	477	....	....	2088	1421	5067	436	412	459	365	.....	.....	20
Means,	28.3	41.2	16.4	....	....	67	46	17	14	13	15	12	.....	.....	...
Perct.	......	.....	.....	....	....	.....	.....	.....	.....	.....	.....	40%	.....	.....	6

INSTRUMENTAL RECORD.

1905.

BAROM.	ANEMOMETER AND ANEMOSCOPE. WIND.							RAIN GAUGE.			
Actual Pressure at 12 M.	Total Velocity.	Sum of Components. N.	S.	W.	E.	Equivalent. Direction.	Miles.	Hours of Fall. Earliest.	Latest.	Total Amount.	Date.
24.070	258	224.1	7.0	60.3	17.5	N. 11° 09′ W.	221.3	0	0	T	1
.240	131	103.3	18.0	12.8	18.0	N. 3° 29′ E.	85.5	0	0	0	2
.112	129	83.7	30.8	21.7	24.4	N. 2° 55′ E.	53.0	0	0	0	3
.005	244	236.8	0	29.3	12.3	N. 4° 06′ W.	237.6	0	0	0	4
.120	103	52.0	30.1	7.9	35.9	N. 51° 58′ E.	35.5	0	0	0	5
.140	172	153.4	5.7	26.8	22.9	N. 1° 31′ W.	147.8	0	0	0	6
.080	99	65.2	20.1	7.1	27.7	N. 24° 33′ E.	49.5	...	...	.01	7
23.911	110	78.9	4.8	9.0	37.6	N. 21° 06′ E.	79.4	...	...	.01	8
24.081	162	8.1	111.4	0	104.6	S. 45° 22′ E.	147.0	0	0	0	9
23.869	227	195.1	10.8	21.1	11.7	N. 2° 55′ W.	184.7	0	0	T	10
.799	263	258.3	1.6	20.7	4.9	N. 3° 31′ W.	257.4	0	0	T	11
24.022	76	...	...	...	...	...	...	0	0	T	12
.248	...	...	...	...	...	...	...	0	0	0	13
.420	...	...	...	...	...	...	...	0	0	0	14
.180	...	...	...	...	...	...	...	0	0	0	15
.091	88	70.4	6.1	8.6	18.7	N. 8° 56′ E.	65.0	0	0	0	16
23.881	296	254.4	0	138.5	0	N. 28° 34′ W.	289.7	10 a.m.	5 p.m.	.14	17
24.107	184	172.5	0	17.3	25.4	N. 2° 41′ E.	172.9	0	0	0	18
.015	128	68.6	31.8	36.5	28.5	N. 12° 16′ W.	37.6	0	0	0	19
23.966	210	110.5	55.5	64.8	51.1	N. 13° 59′ W.	56.6	0	0	0	20
.941	140	66.1	55.5	16.2	39.5	N. 65° 32′ E.	25.6	0	0	0	21
24.078	177	106.8	34.8	59.0	22.8	N. 26° 42′ W.	80.5	0	0	0	22
.115	319	172.2	50.6	140.5	57.6	N. 34° 17′ W.	147.2	0	0	0	23
.294	104	32.4	45.7	4.2	55.7	S. 75° 31′ E.	53.1	0	0	0	24
.317	88	5.4	67.1	5.8	40.8	S. 29° 34′ E.	70.9	...	...	.01	25
.209	133	97.2	21.6	22.9	18.0	N. 3° 43′ W.	75.7	0	0	0	26
.063	140	106.5	21.5	21.8	15.1	N. 4° 31′ W.	85.2	0	0	0	27
.006	195	173.9	0	53.1	17.6	N. 11° 32′ W.	177.5	0	0	0	28
.037	170	51.3	87.6	12.0	76.4	S. 60° 35′ E.	73.9	0	0	T	29
23.930	218	21.1	138.0	5.8	134.5	S. 47° 45′ E.	173.9	0	0	0	30
.970	210	144.7	45.3	4.9	52.5	N. 25° 35′ E.	110.2	0	0	0	31
746.317	4774	3112.9	901.4	828.6	971.7	...	...	...	...	.17	...
24.075	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...

MONTHLY SUMMARY OF

FEBRUARY,

DATE.	THERMOMETERS. Temperatures. Mean of 24 h.	Extremes. Max.	Extremes. Min.	Hours of Extremes. Max.	Hours of Extremes. Min.	PSYCHROMETER. Relative Humidity. 6 A.M.	12 M.	6 P.M.	Dew-point. 6 A.M.	12 M.	6 P.M.	Clouds at Observ'n.	SUNSHINE RECORD' Number of Minutes. Actual.	Possible.	Per ct.
1	1.9	10	-4	3 a.m.	12 n't	95	83	71	2	2	-6	24	421	570	74
2	-4.3	1	-9	4 p.m.	12 n't	92	71	70	-7	-6	-8	10	283	572	49
3	-0.3	12	-11	2 p.m.	5 a.m.	41	51	56	-23	-3	5	8	382	574	67
4	13.7	29	-2	9 p.m.	1 a.m.	20	43	38	26	6	9	16	390	576	68
5	20.8	26	13	10 a.m.	12 n't	86	75	87	16	17	17	29	129	578	22
6	9.5	13	5	1 a.m.	12 n't	92	63	85	8	2	5	8	410	581	71
7	11.8	24	5	5 p.m.	12 n't	92	82	60	6	7	10	23	181	583	31
8	24.8	38	4	1 p.m.	1 a.m.	35	39	39	12	16	3	12	472	585	81
9	18.5	26	10	2 p.m.	8 a.m.	43	63	53	-3	12	2	13	482	587	82
10	15.7	25	6	3 p.m.	7 a.m.	96	69	56	9	7	5	17	338	590	57
11	-5.2	10	-18	1 a.m.	12 n't	95	45	77	1	-18	-18	30	300	592	51
12	-15.2	-7	-22	3 p.m.	10 p.m.	75	82	55	-21	-14	-24	9	531	594	89
13	6.8	28	-20	3 p.m.	1 a.m.	33	48	51	-27	5	1	0	563	595	95
14	19.7	32	6	2 a.m.	12 n't	44	36	36	1	5	4	0	576	597	96
15	23.2	39	4	3 p.m.	3 a.m.	62	31	58	0	11	22	14	441	599	74
16	29.6	40	19	11 a.m.	12 n't	38	59	77	11	23	20	19	328	602	54
17	17.8	22	15	3 p.m.	8 a.m.	87	72	86	12	11	16	28	362	605	60
18	24.6	44	10	1 p.m.	5 a.m.	81	34	61	6	15	20	2	559	609	92
19	32.2	51	16	12 m.	4 a.m.	57	25	40	15	12	18	0	583	612	95
20	41.0	59	26	4 p.m.	6 a.m.	60	14	22	18	8	16	8	568	615	92
21	36.5	47	27	11 a.m.	8 a.m.	69	35	56	20	19	25	7	557	617	90
22	39.0	57	27	3 p.m.	5 a.m.	60	38	40	18	26	25	10	477	619	77
23	43.2	58	31	3 p.m.	2 a.m.	34	26	42	15	20	28	19	405	622	65
24	39.7	50	28	2 p.m.	12 n't	37	10	53	14	-10	28	0	606	627	97
25	40.3	57	27	3 p.m.	4 a.m.	79	31	41	24	23	26	2	591	628	94
26	39.3	52	30	3 p.m.	12 n't	24	39	85	14	23	34	14	488	630	77
27	33.5	44	22	3 p.m.	8 a.m.	77	63	86	18	28	39	7	571	634	90
28	41.6	57	30	2 p.m.	7 a.m.	62	29	56	21	23	25	9	590	635	93
Sums,	599.7	944	275	....	....	1766	1356	1637	154	270	347	338	.....	.....	210
Means,	21.4	33.7	9.8	....	....	63	48	58	6	10	12	12	.....	.....	....
Perctg.	.....	.....	.....	....	....	.....	.....	.....	.....	.....	.....	40%	.....	.....	75

INSTRUMENTAL RECORD.

1905.

BAROM.	ANEMOMETER AND ANEMOSCOPE.							RAIN GAUGE.			DATE.
	WIND.										
Actual Pressure at 12 M.	Total Velocity.	Sum of Components.				Equivalent.		Hours of Fall.		Total Amount.	
		N.	S.	W.	E.	Direction.	Miles.	Earliest.	Latest.		
24.105	224	...	...	...	...	...	...	0	0	.02	1
23.829	115	...	...	...	...	...	...	0	0	0	2
.876	65	...	...	...	...	...	...	0	0	0	3
.621	162	...	...	...	...	...	...	0	0	0	4
.856	176	...	...	...	...	...	...	0	0	T	5
.891	107	...	...	...	...	...	...	0	0	.02	6
.796	168	...	...	...	...	...	...	...	...	.60	7
.595	490	...	...	...	...	...	...	0	0	0	8
.908	...	...	...	...	...	...	...	0	0	0	9
.770	86	...	...	...	...	...	...	...	12 m.	.10	10
.779	261	...	...	...	...	...	...	...	9 a.m.	.05	11
.923	144	...	...	...	...	...	...	0	0	0	12
.947	156	...	...	...	...	...	...	0	0	0	13
24.167	220	...	...	...	...	...	...	0	0	0	14
.074	126	...	...	...	...	...	...	0	0	0	15
23.982	154	...	...	...	...	...	...	0	0	0	16
24.218	112	...	...	...	...	...	...	...	...	.17	17
.033	108	...	...	...	...	...	...	0	0	0	18
.118	152	...	...	...	...	...	...	0	0	0	19
.145	236	...	...	...	...	...	...	0	0	0	20
.342	139	...	...	...	...	...	...	0	0	0	21
.181	141	...	...	...	...	...	...	0	0	0	22
.037	159	...	...	...	...	...	...	0	0	0	23
.288	161	...	...	...	...	...	...	0	0	0	24
.211	164	...	...	...	...	...	...	0	0	0	25
.083	238	...	...	...	...	...	...	4 p.m.	7 p.m.	.18	26
.244	161	...	...	...	...	...	...	0	0	0	27
.119	127	...	...	...	...	...	...	0	0	0	28
672.138	4552	...	...	...	...	...	...	...	...	1.14	...
24.005	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...

MONTHLY SUMMARY OF

MARCH,

Date.	Thermometers. Temperatures. Mean of 24 h.	Extremes. Max.	Extremes. Min.	Hours of Extremes. Max.	Hours of Extremes. Min.	Psychrometer. Relative Humidity. 6 A.M.	12 M.	6 P.M.	Dew-point. 6 A.M.	12 M.	6 P.M.	Clouds at Observ'n.	Sunshine Record. Number of Minutes. Actual.	Possible.	Per ct.
1	44.5	58	37	2 p.m.	4 a.m.	62	34	56	26	28	37	25	390	638	61
2	44.2	61	34	3 p.m.	6 a.m.	60	40	37	24	32	28	18	396	642	62
3	47.4	59	38	12 m.	2 a.m.	65	25	36	30	24	26	18	357	644	55
4	45.9	59	33	4 p.m.	6 a.m.	43	16	46	16	13	33	4	610	647	94
5	43.2	56	33	2 p.m.	3 a.m.	58	41	80	28	29	38	15	382	649	59
6	42.8	56	36	3 p.m.	6 a.m.	61	43	40	25	31	27	12	519	652	80
7	29.5	36	26	1 a.m.	12 n't	80	72	79	25	25	24	23	318	654	49
8	31.3	43	21	4 p.m.	7 a.m.	75	33	55	16	13	24	2	600	658	91
9	36.8	49	25	3 p.m.	1 a.m.	60	67	75	18	33	28	7	570	660	86
10	29.8	34	26	10 a.m.	12 n't	74	90	90	27	29	27	29	303	662	46
11	32.8	48	25	5 p.m.	6 a.m.	89	72	66	23	25	31	22	.....	663	....
12	28.0	31	26	5 p.m.	4 a.m.	89	89	90	24	26	29	30	0	666	0
13	37.5	56	22	4 p.m.	7 a.m.	88	30	47	20	21	25	1	592	669	88
14	41.2	56	30	10 a.m.	2 a.m.	57	46	100	27	32	43	26	295	671	44
15	39.3	43	34	1 p.m.	12 n't	86	93	92	36	40	36	30	0	677	0
16	40.2	47	34	4 p.m.	4 a.m.	86	59	60	36	29	30	16	433	681	64
17	40.2	46	37	12 m.	10 p.m.	92	87	93	36	41	38	28	200	683	29
18	38.2	44	34	2 p.m.	12 n't	71	65	92	31	30	35	26	164	686	24
19	35.4	46	29	6 p.m.	8 a.m.	100	75	71	29	28	31	27	136	687	20
20	37.2	42	32	9 a.m.	12 n't	77	92	70	32	33	30	21	222	689	32
21	44.8	61	30	4 p.m.	5 a.m.	72	28	39	24	25	31	5	587	691	85
22	37.8	52	28	5 a.m.	12 n't	66	38	73	25	19	26	20	223	694	32
23	36.2	46	26	4 p.m.	3 a.m.	50	19	67	14	5	33	8	623	695	90
24	45.9	61	29	2 p.m.	1 a.m.	82	17	36	30	13	26	8	529	697	76
25	46.9	58	37	5 p.m.	7 a.m.	61	26	31	25	20	23	8	624	698	89
26	52.8	67	38	3 p.m.	4 a.m.	41	35	26	22	36	25	14	539	700	77
27	41.3	56	28	1 a.m.	12 n't	30	31	100	21	20	28	18	456	703	65
28	32.4	44	19	4 p.m.	6 a.m.	74	59	57	15	35	27	9	643	705	91
29	40.3	57	22	4 p.m.	4 a.m.	65	27	23	15	18	18	15	571	709	81
30	50.2	57	41	2 p.m.	6 a.m.	40	22	31	21	18	23	16	565	715	79
31	43.5	52	36	3 p.m.	7 a.m.	62	45	93	26	30	39	22	391	718	54
Sums,	1237.5	1581	946	....	....	2116	1516	1951	777	801	919	523	.....	.....	180
Means,	39.9	51.0	30.5	....	....	68	49	63	25	26	30	17	.....	.....	....
Perctg.	......	......	......	....	....	......	......	......	......	......	......	57%	....	.....	60

INSTRUMENTAL RECORD

1905.

Barom.	Anemometer and Anemoscope.							Rain Gauge.			
	Wind.										
Actual Pressure at 12 M.	Total Velocity.	Sum of Components.				Equivalent.		Hours of Fall.		Total Amount.	Date.
		N.	S.	W.	E.	Direction.	Miles.	Earliest.	Latest.		
24.208	171	153.3	0	5.9	48.9	N. 15° 40′ E.	159.2	0	0	0	1
.275	196	97.2	66.7	2.3	76.9	N. 67° 46′ E.	80.2	0	0	0	2
.090	193	......	......	......	......	......	......	0	0	0	3
.039	......	......	......	......	......	......	......	0	0	0	4
.109	......	......	......	......	......	......	......	0	0	T	5
.049	......	......	......	......	......	......	......	......	......	.06	6
.157	......	......	......	......	......	......	......	0	0	T	7
.184	......	......	......	......	......	......	......	0	0	T	8
23.984	......	......	......	......	......	......	......	0	0	0	9
24.010	275	139.9	78.8	8.5	125.9	N. 62° 30′ E.	132.3	0	0	T	10
23.913	91	......	......	......	......	......	......	0	0	T	11
24.115	......	......	......	......	......	......	......	0	0	T	12
23.950	160	24.3	92.2	10.6	92.7	S. 50° 24′ E.	106.5	0	0	0	13
.893	185	66.7	37.0	87.3	33.6	N. 61° 03′ W.	61.3	0	0	0	14
24.010	256	247.6	3.0	23.9	6.9	N. 3° 59′ W.	245.0	......	......	.66	15
23.982	219	81.7	89.0	3.3	103.4	S. 85° 50′ E.	100.4	0	0	T	16
.648	253	120.0	44.0	133.5	51.3	N. 47° 15′ W.	112.0	......	......	.21	17
.788	454	356.1	2.5	250.8	6.5	N. 43° 56′ W.	352.2	......	......	.34	18
.785	114	21.2	50.9	9.8	70.6	S. 63° 58′ E.	67.6	0	0	0	19
.939	299	276.7	0	82.5	4.8	N. 15° 41′ W.	287.4	......	2 p.m.	.12	20
.919	158	84.9	42.6	44.5	29.2	N. 19° 53′ W.	44.9	0	0	0	21
.857	......	......	......	......	......	......	......	0	0	T	22
24.116	168	96.3	25.2	44.6	38.4	N. 4° 59′ W.	71.3	0	0	T	23
23.888	258	127.1	35.6	158.0	22.0	N. 56° 04′ W.	163.9	0	0	0	24
24.023	258	64.6	84.5	107.3	81.7	S. 52° 08′ W.	32.4	0	0	0	25
23.896	259	22.7	140.1	140.8	45.1	S. 39° 11′ W.	151.5	0	0	T	26
.477	500	139.8	148.5	343.5	0	S. 88° 33′ W.	343.7	3 p.m.	7 p.m.	.12	27
.902	153	94.4	8.5	14.5	18.6	N. 2° 44′ E.	86.0	0	0	0	28
.807	172	36.7	91.6	15.9	68.3	S. 43° 40′ E.	75.8	0	0	0	29
.605	427	0	342.0	158.0	59.7	S. 16° 02′ W.	355.9	0	0	0	30
.875	184	54.0	58.5	40.2	92.6	S. 85° 06′ E.	52.6	0	0	.90	31
742.493	5403	2305.2	1441.2	1685.7	1077.1	......	3082.1	......	......	2.41	......
23.951	......	......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......	......	......

MONTHLY SUMMARY OF

APRIL,

DATE.	THERMOMETERS.					PSYCHROMETER.						SUNSHINE RECORD'R			
	TEMPERATURES.			Hours of Extremes.		Relative Humidity.			Dew-point.			Clouds at Observ'n.	Number of Minutes.		
	Mean of 24 h.	Extremes.													
		Max.	Min.	Max.	Min.	6 A.M.	12 M.	6 P.M.	6 A.M.	12 M.	6 P.M.		Ac-tual.	Pos-sible.	Per ct.
1	35.5	44	30	3 p.m.	12 n't	100	92	95	35	33	31	30	138	721	19
2	33.1	38	29	11 a.m.	3 a.m.	74	83	82	27	31	30	24	92	724	13
3	31.0	44	23	12 m.	7 a.m.	77	74	61	20	27	20	13	267	728	37
4	28.7	35	21	4 p.m.	6 a.m.	88	62	58	19	21	22	6	492	730	67
5	39.9	54	24	3 p.m.	6 p.m.	59	25	40	17	18	27	2	633	733	86
6	49.4	63	31	4 p.m.	5 a.m.	17	14	24	10	14	22	0	640	735	87
7	52.0	65	37	3 p.m.	6 a.m.	57	10	19	27	8	18	3	569	739	77
8	55.5	66	41	4 p.m.	7 a.m.	28	52	18	20	47	18	1	628	741	85
9	54.8	64	44	4 p.m.	12 n't	41	21	42	26	22	35	20	479	744	64
10	33.3	44	28	1 a.m.	12 n't	91	92	95	31	31	30	30	0	748	0
11	27.9	30	25	6 p.m.	7 a.m.	100	95	90	26	27	29	30	0	752	0
12	40.1	53	26	3 p.m.	6 a.m.	81	42	52	26	28	31	17	491	754	65
13	47.2	59	34	4 p.m.	6 a.m.	59	26	32	23	22	24	13	544	756	72
14	40.4	55	32	12 m.	12 n't	75	50	67	29	24	26	17	447	759	59
15	38.0	55	26	3 p.m.	6 a.m.	89	47	50	26	29	29	21	375	762	49
16	29.1	32	26	11 p.m.	9 a.m.	89	87	90	24	24	29	30	0	765	0
17	38.4	50	28	3 p.m.	6 a.m.	90	51	55	37	30	24	21	488	767	64
18	37.5	51	30	5 p.m.	6 a.m.	90	92	70	38	34	39	24	128	769	17
19	49.2	61	34	1 p.m.	3 a.m.	52	14	16	31	14	8	3	491	771	64
20	35.0	46	28	8 a.m.	12 n't	31	67	63	16	26	22	17	403	773	52
21	37.5	51	23	5 p.m.	6 a.m.	21	33	39	-3	20	23	10	607	776	78
22	44.8	56	32	2 p.m.	6 a.m.	60	31	48	24	27	31	26	241	778	31
23	38.1	42	32	1 a.m.	12 n't	100	93	92	37	39	36	30	0	782	0
24	32.3	36	30	4 p.m.	8 a.m.	90	82	67	29	30	26	29	230	785	29
25	36.7	49	22	5 p.m.	5 a.m.	89	66	69	24	31	37	20	516	788	65
26	50.6	65	33	5 p.m.	4 a.m.	78	30	31	34	30	30	9	587	791	74
27	57.6	68	46	3 p.m.	6 a.m.	33	17	38	26	21	32	5	699	794	88
28	52.8	61	41	1 p.m.	12 n't	33	40	20	26	32	16	10	672	797	84
29	50.6	63	34	4 p.m.	5 a.m.	76	22	38	31	24	32	1	707	799	88
30	58.7	73	38	5 p.m.	5 a.m.	44	16	21	29	22	27	1	701	800	88
Sums,	1255.7	1573	928	....	....	2012	1526	1582	755	786	807	463	.....	.....	1602
Means,	41.9	52.4	30.9	....	....	67	51	53	25	26	27	15	.....	.....	.....
Perctg.	.....	.....	.....	....	....	.....	.....	.....	.....	.....	.....	50%	.....	.....	53%

INSTRUMENTAL RECORD.

1905.

Barom.	Anemometer and Anemoscope.							Rain Gauge.			
	Wind.							Hours of Fall.			
Actual Pressure at 12 m.	Total Velocity.	Sum of Components.				Equivalent.				Total Amount.	Date.
		N.	S.	W.	E.	Direction.	Miles.	Earliest.	Latest.		
23.851	246	196.5	9.8	76.2	32.2	N. 13° 16′ W.	191.8	....	7 p.m.	1.36	1
.851	......	......	......	......	......	....	......	10 a.m.	....	.20	2
24.019	284	253.3	5.2	71.0	14.0	N. 12° 56′ W.	254.6	0	0	T	3
.179	222	211.6	0	8.9	39.8	N. 8° 19′ E.	213.7	0	0	T	4
.008	169	154.2	2.1	8.1	33.5	N. 9° 29′ E.	154.2	0	0	0	5
.037	208	163.0	0	101.2	3.1	N. 31° 03′ W.	190.2	0	0	0	6
.037	189	112.3	1.9	128.0	0.1	N. 49° 12′ W.	169.0	0	0	0	7
23.973	222	82.0	14.4	181.2	6.1	N. 68° 54′ W.	187.8	0	0	0	8
.766	......	......	......	......	......	....	......	0	0	0	9
.843	229	85.9	87.0	4.9	117.6	S. 89° 27′ E.	113.7	....	....	.10	10
.950	200	0	125.8	0	150.7	S. 50° 13′ E.	196.3	....	....	.30	11
.762	151	52.3	68.0	21.6	54.3	S. 64° 21′ E.	36.2	0	0	0	12
.758	195	91.4	50.0	33.0	69.2	N. 39° 12′ E.	57.2	0	0	0	13
.881	274	226.3	18.8	11.3	62.7	N. 13° 55′ E.	213.7	0	0	0	14
24.100	183	67.8	60.8	11.1	105.5	N. 85° 46′ E.	94.7	0	0	T	15
.123	260	0	179.4	10.9	172.5	S. 42° 01′ E.	241.5	....	2 p.m.	.07	16
.086	202	14.3	125.6	7.7	125.2	S. 46° 33′ E.	161.8	7 p.m.	10 p.m.	.08	17
.089	160	17.9	91.4	15.5	89.0	S. 45° 00′ E.	73.5	0	0	0	18
23.715	393	80.9	187.3	230.7	33.1	S. 61° 42′ W.	224.4	0	0	0	19
.922	......	......	......	......	......	....	......	0	0	T	20
24.048	......	......	......	......	......	....	......	0	0	0	21
23.997	148	27.7	91.6	5.1	69.4	S. 45° 11′ E.	90.6	0	0	0	22
.973	200	142.2	18.0	74.5	20.8	N. 23° 23′ W.	135.3	0	0	0	23
24.065	361	320.3	0	106.4	5.6	N. 17° 28′ W.	335.8	....	11 a.m.	2.35	24
23.930	92	65.5	8.5	19.7	14.6	N. 5° 07′ W.	57.2	0	0	0	25
.827	140	56.5	61.2	20.4	34.6	S. 71° 41′ E.	14.9	0	0	T	26
.859	173	67.0	59.8	76.2	20.4	N. 82° 39′ W.	56.2	0	0	0	27
.899	234	51.2	117.0	36.2	112.3	S. 49° 09′ E.	100.6	0	0	0	28
24.037	171	62.7	83.6	8.2	65.0	S. 69° 48′ E.	60.5	0	0	0	29
.035	220	53.7	128.4	21.4	66.0	S. 30° 50′ E.	87.0	0	0	0	30
718.620	5526	2659.5	1595.6	1289.4	1517.3	....	.....	....	....	4.46	......
23.954	......	......	......	......	......	....	......	....	....	....	......
......	......	......	......	......	......	....	......	....	....	....	......

MONTHLY SUMMARY OF

May,

Date.	Thermometers.					Psychrometer.						Sunshine Record'r			
	Temperatures.			Hours of Extremes.		Relative Humidity.			Dew-point.			Clouds at Observ'n.	Number of Minutes.		
	Mean of 24 h.	Extremes. Max.	Extremes. Min.	Max.	Min.	6 A.M.	12 M.	6 P.M.	6 A.M	12 M.	6 P.M.		Actual.	Possible	Per ct.
1	59.9	69	50	5 p.m.	6 a.m.	36	17	26	26	21	29	10	481	802	60
2	55.7	63	44	1 p.m.	12 n't	55	30	49	30	30	37	13	558	804	69
3	41.1	55	34	5 p.m.	12 n't	92	66	32	36	32	24	26	293	807	36
4	39.1	51	32	4 p.m.	12 n't	73	39	77	26	23	32	15	409	808	51
5	34.6	49	29	7 p.m.	7 a.m.	90	75	61	28	28	31	19	575	810	71
6	47.5	59	33	5 p.m.	2 a.m.	66	42	48	31	30	36	7	653	813	80
7	52.9	67	36	6 p.m.	4 a.m.	65	24	18	30	26	21	7	715	816	88
8	....	72	39	......	5 a.m.	44	17	16	25	19	22	6	693	819	85
9	54.8	64	47	1 a.m.	12 n't	45	18	29	35	16	23	13	654	822	80
10	48.5	58	35	2 p.m.	6 a.m.	68	29	38	27	23	29	14	701	826	85
11	44.3	54	35	4 p.m.	6 a.m.	52	34	36	21	25	26	8	717	827	87
12	49.6	62	33	4 p.m.	5 a.m.	68	23	25	27	22	24	4	681	829	82
13	46.8	56	38	3 p.m.	6 a.m.	86	45	....	36	30	....	22	412	832	50
14	51.9	65	35	5 p.m.	5 a.m.	59	19	32	35	23	28	2	752	833	90
15	....	69	46	......	6 a.m.	18	17	31	16	21	30	2	751	834	90
16	....	60	41	4 p.m.	12 n't	46	37	30	28	31	28	0	740	835	89
17	52.8	69	36	4 p.m.	5 a.m.	32	25	44	22	30	38	16	533	836	64
18	53.5	66	46	10 a.m.	4 a.m.	55	47	38	41	43	29	18	336	837	40
19	49.6	56	42	3 p.m.	5 a.m.	46	70	94	33	41	48	22	....	839	....
20	50.4	59	44	5 p.m.	12 n't	94	88	77	45	49	45	27	....	839	....
21	52.1	66	41	2 p.m.	5 a.m.	87	50	57	44	44	40	22	....	841	....
22	52.7	63	45	4 p.m.	5 a.m.	76	29	73	43	29	46	24	442	843	52
23	57.9	70	46	2 p.m.	3 a.m.	68	23	48	44	30	40	12	608	845	72
24	57.8	71	46	5 p.m.	4 a.m.	51	31	41	39	35	26	15	549	846	65
25	53.0	61	45	3 p.m.	4 a.m.	59	47	64	36	39	45	13	632	846	75
26	55.0	67	49	2 p.m.	4 a.m.	77	36	84	46	38	51	16	....	849	....
27	55.0	63	45	3 p.m.	5 a.m.	54	57	95	34	46	53	20	649	851	76
28	56.2	67	48	1 p.m.	10 p.m.	74	25	23	49	28	20	15	....	853	....
29	53.2	67	37	4 p.m.	5 a.m.	68	22	32	38	26	31	13	....	854	....
30	53.8	62	44	5 p.m.	5 a.m.	87	64	52	43	45	42	14	652	855	76
31	61.0	76	49	6 p.m.	5 a.m.	83	19	52	48	23	48	8	675	856	79
Sums,	1440.7	1956	1270	....	....	1974	1165	1422	1062	946	1022	423	.....	.....	1792
Means,	51.5	63.1	41.0	....	....	64	38	47	34	31	34	14	.....	.....	.....
Perctg.	......	.....	.....	......	......	.....	.....	.....	.....	.....	.....	47%	.....	.....	72%

INSTRUMENTAL RECORD.

1905.

BAROM.	ANEMOMETER AND ANEMOSCOPE.							RAIN GAUGE.			DATE.
	WIND.							Hours of Fall.		Total Amount.	
Actual Pressure at 12 M.	Total Velocity.	Sum of Components.				Equivalent.		Earliest.	Latest.		
		N.	S.	W.	E.	Direction.	Miles.				
23.865	210	21.7	146.9	75.5	22.8	S. 22° 50′ W.	135.8	0	0	0	1
.589	326	43.4	193.2	136.9	26.9	S. 36° 17′ W.	185.9	0	0	0	2
.511	292	253.7	14.8	23.5	44.7	N. 5° 04′ E.	240.0	....	10 a.m.	.15	3
.815	258	85.9	122.8	3.7	117.9	S. 72° 06′ E.	120.0	0	0	T	4
.913	170	28.7	69.4	6.1	122.3	S. 70° 42′ E.	123.1	....	11 a.m.	.60	5
24.091	163	26.5	101.9	30.5	56.0	S. 18° 41′ E.	79.6	0	0	0	6
.047	148	41.6	70.8	2.2	71.8	S. 67° 14′ E.	75.4	0	0	0	7
23.807	271	31.0	192.9	8.8	104.5	S. 30° 35′ E.	188.1	0	0	0	8
.562	381	83.1	122.2	283.3	6.8	S. 81° 57′ W.	279.2	0	0	0	9
.655	275	36.1	204.4	72.8	33.6	S. 13° 07′ W.	172.8	0	0	0	10
.906	299	121.7	132.0	8.8	123.1	S. 84° 51′ E.	114.8	0	0	0	11
.917	214	79.1	93.4	10.4	94.9	S. 80° 24′ E.	85.7	0	0	0	12
.874	331	299.8	2.0	60.1	28.0	N. 6° 09′ W.	299.6	4 p.m.	6 p.m.	.02	13
24.001	181	104.5	26.1	76.3	34.1	N. 28° 17′ W.	89.0	0	0	0	14
.089	259	110.6	16.8	124.2	88.0	N. 21° 06′ W.	100.6	0	0	0	15
.196	173	48.1	82.6	0	96.8	S. 70° 23′ E.	102.8	0	0	0	16
23.951	165	54.3	57.2	31.8	69.9	S. 85° 39′ E.	38.2	0	0	0	17
.905	190	139.4	23.7	28.6	43.0	N. 7° 06′ E.	116.6	11 a.m.	....	.02	18
24.087	......	......	......	......	......	....	.....	....	....	.14	19
.021	......	......	......	......	......	....	.....	0	0	0	20
23.896	......	......	......	......	......	....	.....	....	6 p.m.	.31	21
24.014	213	15.5	119.1	3.5	150.8	S. 54° 51′ E.	180.1	5 p.m.	8 p.m.	.46	22
23.997	120	54.8	33.8	15.2	53.7	N. 61° 23′ E.	43.8	0	0	0	23
.939	165	86.4	42.1	26.5	47.6	N. 25° 28′ E.	49.0	0	0	T	24
24.055	242	72.3	128.7	2.3	115.0	S. 63° 25′ E.	126.1	0	0	T	25
23.900	......	......	......	......	......	....	.....	0	0	T	26
.967	......	......	......	......	......	....	.....	6 p.m.	7 p.m.	.27	27
.805	......	......	......	......	......	....	.....	0	0	T	28
24.017	......	......	......	......	......	....	.....	8 p.m.	11 p.m.	.41	29
.241	176	17.1	110.8	0.6	127.6	S. 53° 35′ E.	157.8	0	0	0	30
.145	132	9.8	78.2	6.6	83.3	S. 48° 17′ E.	102.8	0	0	0	31
741.778	5354	1865.1	2185.8	1038.2	1763.1	....	.....	....	....	2.38	......
23.928	......	......	......	......	......	....	.....	....	....	......	......
....	......	......	......	......	......	....	.....	....	....	......	......

MONTHLY SUMMARY OF

JUNE,

Date.	Thermometers.					Psychrometer.						Sunshine Record'r			
	Temperatures.			Hours of Extremes.		Relative Humidity.			Dew-point.			Clouds at Observ'n.	Number of Minutes.		
	Mean of 24 h.	Extremes. Max.	Min.	Max.	Min.	6 A.M.	12 M.	6 P.M.	6 A.M.	12 M.	6 P.M.		Actual.	Possible.	Per ct.
1	64.3	78	49	1 p.m.	4 a.m.	60	24	52	45	38	47	22	498	856	58
2	65.5	78	50	3 p.m.	4 a.m.	53	19	29	44	31	31	10	733	857	86
3	68.3	81	50	3 p.m.	4 a.m.	44	32	21	47	45	30	13	713	857	83
4	68.1	82	54	3 p.m.	4 a.m.	56	25	16	50	39	28	9	811	859	94
5	65.8	79	51	5 p.m.	5 a.m.	63	13	11	50	22	21	0	831	859	97
6	59.1	69	44	4 p.m.	4 a.m.	72	27	31	45	31	35	0	829	860	96
7	59.2	71	49	3 p.m.	5 a.m.	56	44	84	43	47	54	9	524	861	61
8	63.6	75	54	4 p.m.	5 a.m.	89	54	49	55	52	52	26	236	862	27
9	66.0	75	54	11 a.m.	12 n't	48	41	48	45	46	50	19	616	862	71
10	60.6	72	46	4 p.m.	5 a.m.	83	33	53	48	49	49	6	719	862	83
11	60.1	70	47	4 p.m.	5 a.m.	77	60	44	45	50	47	6	766	863	89
12	......	75	47	....	5 a.m.	75	58	37	47	55	43	13	530	863	61
13	64.8	77	48	12 m.	4 a.m.	50	25	21	44	39	32	17	594	863	69
14	65.3	80	46	4 p.m.	5 a.m.	51	27	27	42	40	40	15	676	863	78
15	......	84	52	....	5 a.m.	58	18	23	47	35	36	17	679	863	79
16	57.8	64	51	5 p.m.	12 n't	78	62	54	47	48	46	24	445	863	52
17	61.2	75	45	5 p.m.	3 a.m.	88	58	32	49	48	43	10	664	863	77
18	60.3	72	46	3 p.m.	4 a.m.	53	38	30	38	41	36	11	692	864	80
19	......	70	50	7 p.m.	6 a.m.	72	43	40	44	46	43	12	608	864	70
20	62.1	72	51	4 p.m.	1 a.m.	79	57	40	52	52	43	22	435	865	50
21	58.0	66	51	2 p.m.	5 a.m.	72	55	62	45	47	48	21	508	865	59
22	64.0	83	49	5 p.m.	6 a.m.	94	55	31	49	53	44	9	686	865	79
23	70.6	88	48	3 p.m.	5 a.m.	68	16	28	46	31	45	6	820	865	95
24	72.0	88	50	4 p.m.	5 a.m.	51	9	13	40	20	30	6	707	864	81
25	64.2	74	54	5 p.m.	5 a.m.	79	19	43	52	26	49	1	822	864	95
26	65.5	81	54	6 p.m.	5 a.m.	75	62	36	55	56	52	11	658	863	76
27	76.3	90	55	4 p.m.	5 a.m.	44	10	11	28	25	28	1	819	863	95
28	76.1	87	64	3 p.m.	3 a.m.	14	11	25	25	23	41	5	794	863	92
29	65.2	75	56	1 p.m.	5 a.m.	85	47	51	55	52	51	20	423	863	49
30	64.6	80	48	4 p.m.	5 a.m.	74	47	36	49	54	47	8	684	863	79
Sums,	1748.6	2311	1513	....	....	1961	1089	1078	1381	1241	1241	349	.....	.....	2261
Means,	64.8	77.0	50.4	....	....	65	36	36	46	41	41	12	.....	.....	....
Perctg.	.....	....	...	..	....	...	...	..	...	..	....	40%	.	.....	75%

INSTRUMENTAL RECORD.

1905.

BAROM.	ANEMOMETER AND ANEMOSCOPE.							RAIN GAUGE.			Date.
	WIND.							Hours of Fall.		Total Amount.	
Actual Pressure at 12 M.	Total Velocity.	Sum of Components. N.	S.	W.	E.	Equivalent. Direction.	Miles.	Earliest.	Latest.		
24.103	120	55.0	30.8	32.5	31.1	N. 3° 18′ W.	24.3	0	0	0	1
.046	150	57.3	62.1	10.4	67.0	S. 85° 13′ E.	57.1	0	0	0	2
.052	140	54.8	59.8	8.3	46.4	S. 82° 31′ E.	38.4	0	0	0	3
23.951	209	40.9	127.2	95.5	14.5	S. 43° 11′ W.	118.4	0	0	0	4
.934	182	70.3	43.0	121.2	12.0	N. 75° 58′ W.	112.6	0	0	0	5
24.129	256	32.4	175.4	5.4	128.7	S. 40° 46′ E.	188.8	0	0	0	6
.122	166	24.4	101.1	8.3	82.8	S. 44° 10′ E.	107.0	3 p.m.	4 p.m	.44	7
.008	106	19.9	63.0	3.2	56.2	S. 50° 53′ E.	68.3	0	0	0	8
23.984	216	118.9	25.0	55.1	60.7	N. 3° 25′ E.	94.0	0	0	T	9
24.118	247	55.3	146.6	1.9	120.3	S. 52° 22′ E.	149.5	0	0	0	10
.182	191	28.3	118.1	9.8	95.3	S. 43° 36′ E.	124.0	0	0	0	11
.094	140	37.6	69.7	29.4	46.5	S. 28° 03′ E.	36.3	6 p.m.	7 p.m.	.04	12
23.956	188	99.1	17.1	95.3	28.1	N. 39° 20′ W.	106.0	0	0	0	13
24.028	145	48.4	66.5	7.3	58.4	S. 70° 30′ E.	54.2	0	0	0	14
23.921	185	81.4	46.9	74.3	28.8	N. 52° 50′ W.	57.1	0	0	0	15
.950	273	70.1	146.7	20.0	130.4	S. 55° 15′ E.	134.4	0	0	0	16
.939	230	8.0	171.7	0	124.0	S. 37° 09′ E.	205.4	0	0	0	17
24.000	257	71.6	142.4	25.1	90.7	S. 42° 49′ E.	96.5	9 p.m.	10 p.m.	.25	18
.088	194	21.7	122.5	0	114.3	S. 48° 35′ E.	152.4	0	0	0	19
.137	129	17.6	75.5	10.2	65.2	S. 43° 32′ E.	79.8	8 p.m.	8 p.m.	.01	20
.139	262	136.0	80.2	9.2	97.8	N. 57° 48′ E.	104.7	1 p.m.	4 p.m.	.07	21
23.910	178	47.2	95.7	30.6	65.5	S. 35° 45′ E.	59.7	0	0	0	22
.920	240	59.5	155.4	24.1	65.7	S. 23° 27′ E.	104.5	0	0	0	23
.937	262	43.9	186.2	94.5	13.4	S. 29° 41′ W.	163.8	0	0	0	24
24.075	324	115.1	136.2	31.4	150.6	S. 79° 58′ E.	121.1	0	0	0	25
.018	231	18.2	153.1	4.7	129.0	S. 42° 39′ E.	183.4	0	0	T	26
23.985	204	65.8	60.0	128.9	7.6	N. 87° 16′ W.	121.5	0	0	0	27
24.062	179	80.8	41.7	32.1	83.8	N. 52° 54′ E.	64.8	0	0	0	28
.055	177	22.0	97.5	0.4	115.0	S. 56° 37′ E.	137.2	0	0	T	29
23.955	147	50.9	59.6	0.2	81.4	S. 83° 53′ E.	81.6	0	0	T	30
720.798	5928	1652.4	2876.7	969 3	2211.2	....	......	......	......	0.81	......
24.027	......	......	......	......	......	....	......	......	......	......	......

MONTHLY SUMMARY OF

JULY.

Date.	Thermometers.					Psychrometer.						Sunshine Record'r			
	Temperatures.			Hours of Extremes.		Relative Humidity.			Dew-point.			Clouds at Observ'n.	Number of Minutes.		
	Mean of 24 h.	Extremes. Max.	Min.	Max.	Min.	6 A.M.	12 M.	6 P.M.	6 A.M.	12 M.	6 P.M.		Actual.	Possible	Per ct.
1	63.6	77	55	2 p.m.	6 a.m.	83	47	41	50	52	45	11	594	863	69
2	60.0	71	49	11 a.m.	5 a.m.	63	41	35	44	45	36	16	675	862	78
3	62.4	74	46	5 p.m.	4 a.m.	36	28	19	33	34	28	4	811	862	94
4	66.0	80	43	2 p.m.	5 a.m.	61	18	19	40	29	31	5	761	860	88
5	62.3	72	49	4 p.m.	6 a.m.	36	33	29	29	38	36	4	800	860	93
6	64.9	80	44	2 p.m.	6 a.m.	61	16	23	39	25	35	9	649	860	75
7	66.0	81	55	2 p.m.	12 n't	47	20	49	39	33	47	11	651	860	76
8	52.1	60	41	4 p.m.	3 a.m.	50	55	77	38	42	46	18	481	859	56
9	58.1	70	46	4 p.m.	5 a.m.	82	29	36	43	34	40	2	774	859	90
10	62.6	79	45	4 p.m.	6 a.m.	82	23	20	43	35	33	0	762	857	89
11	66.8	81	51	4 p.m.	3 a.m.	52	25	23	42	39	38	13	661	857	77
12	68.9	86	55	11 a.m.	6 a.m.	60	19	78	45	37	62	17	686	856	80
13	65.3	79	52	1 p.m.	6 a.m.	68	32	43	46	47	46	19	514	856	60
14	70.7	86	51	3 p.m.	5 a.m.	70	23	24	49	38	42	7	790	854	92
15	70.5	84	55	2 p.m.	5 a.m.	47	19	30	43	37	42	11	786	852	92
16	70.6	85	55	4 p.m.	5 a.m.	48	22	30	45	39	46	3	792	850	93
17	72.8	88	59	4 p.m.	4 a.m.	48	19	27	45	37	44	6	784	849	92
18	69.2	83	57	1 p.m.	5 a.m.	46	28	46	46	45	51	14	640	847	76
19	67.5	81	51	4 p.m.	5 a.m.	64	26	29	45	40	43	12	724	846	86
20	63.4	78	55	3 p.m.	5 a.m.	84	46	54	53	51	52	25	605	844	72
21	64.0	74	57	2 p.m.	5 a.m.	75	51	58	51	50	54	26	435	843	52
22	63.9	76	50	3 p.m.	5 a.m.	73	22	29	46	31	41	0	794	841	94
23	63.1	78	49	2 p.m.	3 a.m.	74	32	57	50	45	51	11	680	839	81
24	64.2	77	56	5 p.m.	7 a.m.	95	47	53	56	54	55	15	570	837	68
25	65.1	81	51	1 p.m.	5 a.m.	62	34	53	49	50	56	14	512	836	61
26	67.5	77	54	1 p.m.	6 a.m.	70	36	64	50	47	61	11	403	836	48
27	64.4	79	53	1 p.m.	6 a.m.	84	37	49	51	50	47	21	455	835	54
28	64.2	81	52	2 p.m.	5 a.m.	74	45	47	50	54	49	14	697	833	84
29	64.0	79	56	1 p.m.	4 a.m.	84	40	85	54	52	57	21	540	831	65
30	60.3	68	58	12 m.	12 n't	80	61	63	55	54	51	29	243	829	29
31	60.1	70	54	2 p.m.	5 a.m.	84	69	90	54	56	57	21	576	827	70
Sums,	2004.5	2415	1604	....	....	2043	1043	1380	1423	1320	1422	390	.....	.....	2334
Means,	64.7	77.9	51.7	....	....	66	34	45	46	43	46	13	.....	.....	.....
Perctg.	.....	.....	.....	....	....	.....	.....	.....	.....	.....	.....	43%	.....	.....	75%

INSTRUMENTAL RECORD.

1905.

BAROM.	ANEMOMETER AND ANEMOSCOPE.							RAIN GAUGE.			DATE.
	WIND.							Hours of Fall.		Total Amount.	
Actual Pressure at 12 M.	Total Velocity.	Sum of Components.				Equivalent.		Earliest.	Latest.		
		N.	S.	W.	E.	Direction.	Miles.				
23.892	256	86.3	120.1	8.3	122.3	S. 73° 29′ E.	118.9	4 p.m.	6 p.m.	.08	1
.977	190	151.3	10.9	33.2	33.5	N. 0° 07′ E.	140.4	0	0	T	2
24.112	247	226.6	4.4	24.0	39.6	N. 4° 01′ E.	222.7	0	0	0	3
.067	160	68.5	48.0	48.9	48.4	N. 1° 24′ W.	20.5	0	0	0	4
.158	143	55.6	52.4	27.7	52.4	N. 82° 37′ E.	24.9	0	0	0	5
.146	98	32.4	40.7	7.8	42.4	S. 76° 31′ E.	35.5	0	0	0	6
.070	142	89.2	8.8	16.9	62.3	N. 29° 27′ E.	92.3	4 p.m.	5 p.m.	.04	7
.299	275	230.2	6.9	99.6	4.4	N. 23° 05′ W.	242.8	2 a.m.	4 a.m.	.46	8
.208	104	81.0	6.4	3.0	41.3	N. 27° 11′ E.	83.8	0	0	0	9
.092	121	104.0	4.1	0.1	37.4	N. 20° 29′ E.	106.6	0	0	0	10
.009	70	38.3	19.5	11.3	12.5	N. 3° 39′ E.	18.8	0	0	T	11
.061	77	48.0	12.1	23.5	11.5	N. 18° 29′ W.	37.8	......	......	.02	12
.138	103	41.9	10.0	63.4	8.7	N. 59° 45′ W.	63.3	0	0	0	13
.110	114	24.9	65.4	24.6	26.6	S. 2° 50′ E.	40.5	0	0	0	14
.175	155	49.2	82.5	26.4	39.2	S. 21° 02′ E.	35.6	0	0	0	15
.142	......	......	......	......	......	......	......	0	0	0	16
.074	141	81.7	14.0	28.2	56.0	N. 22° 20′ E.	73.1	0	0	0	17
.148	177	129.2	11.5	25.7	44.0	N. 8° 50′ E.	119.0	0	0	0	18
.235	171	63.8	46.4	47.0	55.1	N. 24° 58′ E.	19.1	0	0	0	19
.231	98	44.6	32.8	22.2	23.2	N. 4° 51′ E.	11.8	......	......	.47	20
.244	185	179.1	0	11.4	22.8	N. 3° 39′ E.	179.3	......	......	.05	21
.258	113	59.6	31.3	14.5	30.0	N. 28° 43′ E.	32.2	0	0	0	22
.248	149	51.2	65.4	13.0	64.4	S. 74° 33′ E.	53.3	0	0	0	23
.219	100	14.9	56.5	2.4	61.2	S. 54° 43′ E.	72.0	0	0	0	24
.147	173	67.0	54.3	43.3	41.6	N. 7° 37′ W.	12.8	3 p.m.	3 p.m.	.01	25
.151	125	55.7	37.5	31.2	35.0	N. 11° 48′ E.	18.5	0	0	T	26
.110	135	65.1	22.6	21.8	39.0	N. 22° 02′ E.	45.8	2 p.m.	2 p.m.	.04	27
.102	128	67.8	40.2	11.0	44.1	N. 50° 11′ E.	43.1	4 p.m.	5 p.m.	.10	28
.110	122	60.1	16.4	54.0	26.3	N. 32° 22′ W.	51.7	1 p.m.	10 p.m.	.57	29
.240	156	110.5	17.8	37.6	19.9	N. 10° 49′ W.	94.3	......	......	.06	30
.222	......	......	......	......	......	......	......	3 p.m.	4 p.m.	.48	31
748.393	4238	3372.7	938.9	782.0	1145.1	......	......	......	......	2.38	......
24.142	......	......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......	......	......

MONTHLY SUMMARY OF

AUGUST,

DATE.	THERMOMETERS. Temperatures. Mean of 24 h.	Extremes. Max.	Extremes. Min.	Hours of Extremes. Max.	Hours of Extremes. Min.	PSYCHROMETER. Relative Humidity. 6 A.M.	Relative Humidity. 12 M.	Relative Humidity. 6 P.M.	Dew-point. 6 A.M.	Dew-point. 12 M.	Dew-point. 6 P.M.	SUNSHINE RECORD'R. Clouds at Observ'n.	Number of Minutes. Actual.	Number of Minutes. Possible	Per ct.
1	62.6	77	55	1 p.m.	6 a.m.	89	38	63	54	47	51	14	.....	824	.....
2	62.6	73	52	12 m.	4 a.m.	75	52	47	51	53	47	16	614	821	75
3	64.0	78	49	2 p.m.	6 a.m.	64	33	47	46	44	48	9	588	818	72
4	70.2	85	52	3 p.m.	4 a.m.	58	24	33	48	42	48	4	738	817	90
5	64.7	83	54	1 p.m.	6 a.m.	79	32	71	52	49	52	12	503	814	62
6	63.5	73	53	1 p.m.	12 n't	58	44	52	47	47	48	17	490	812	60
7	63.2	77	47	4 p.m.	5 a.m.	55	42	40	47	47	48	5	731	809	90
8	65.4	81	50	2 p.m.	5 a.m.	64	20	39	46	35	45	9	726	807	90
9	66.2	80	51	3 p.m.	6 a.m.	72	21	34	45	35	44	9	739	805	92
10	64.9	79	51	12 m.	5 a.m.	49	32	59	37	45	49	20	547	803	68
11	61.1	73	54	1 p.m.	5 a.m.	57	41	64	44	46	54	20	549	800	69
12	61.4	71	50	1 p.m.	5 a.m.	73	44	54	47	47	50	13	.....	798	.....
13	65.7	79	50	12 m.	4 a.m.	64	22	33	45	37	41	15	705	796	89
14	......	79	50	11 a.m.	4 a.m.	60	26	32	44	38	43	9	752	794	95
15	......	80	52	....	.....	60	18	.....	44	32	.....	.....	646	792	82
16	69.4	82	58	2 p.m.	12 n't	37	21	34	34	37	44	6	715	790	91
17	71.6	86	52	5 p.m.	5 a.m.	56	13	16	43	30	35	0	775	787	98
18	64.8	74	54	4 p.m.	12 n't	80	52	42	53	52	47	4	714	783	91
19	66.6	80	51	4 p.m.	4 a.m.	64	34	44	46	46	52	8	659	780	84
20	70.2	87	52	3 p.m.	5 a.m.	69	20	17	48	39	33	4	704	776	91
21	71.1	90	54	1 p.m.	6 a.m.	52	11	22	42	28	37	6	686	773	89
22	71.4	85	55	2 p.m.	5 a.m.	60	19	44	44	37	31	11	595	772	77
23	69.3	82	60	12 m.	5 a.m.	57	27	41	46	44	48	20	492	770	64
24	69.4	80	57	3 p.m.	4 a.m.	58	37	47	47	50	54	8	723	769	94
25	69.1	83	58	4 p.m.	6 a.m.	56	38	34	43	51	47	5	695	769	90
26	72.8	88	59	3 p.m.	5 a.m.	60	20	28	50	39	45	5	723	764	95
27	70.3	86	57	2 p.m.	4 a.m.	54	27	49	45	47	52	14	649	760	85
28	69.9	81	57	12 m.	5 a.m.	56	35	31	43	49	44	18	563	757	74
29	71.6	88	56	1 p.m.	5 a.m.	52	21	39	42	43	50	10	641	755	85
30	68.1	83	55	4 p.m.	6 a.m.	79	79	51	50	50	50	13	592	753	78
31	70.8	87	54	5 p.m.	6 a.m.	60	20	30	44	41	42	15	687	750	92
Sums,	1952.0	2510	1659	....	....	1927	963	1243	1417	1327	1379	319	.....	.....	2412
Means,	67.3	81.0	53.5	....	....	62	31	41	46	43	46	11	.....	.....	.....
Perctg.	......	.....	.....	....	....	.....	.....	.....	.....	.....	.....	37%	.....	.....	83%

INSTRUMENTAL RECORD.

1905.

BAROM. Actual Pressure at 12 M.	ANEMOMETER AND ANEMOSCOPE. WIND. Total Velocity.	Sum of Components. N.	S.	W.	E.	Equivalent. Direction.	Miles.	RAIN GAUGE. Hours of Fall. Earliest.	Latest.	Total Amount.	DATE.
24.200	......	......	......	......	......	....	......	....	....	.02	1
.25	97	48.9	37.6	6.8	25.4	N. 58° 43′ E.	21.7	....	....	.01	2
.20	107	42.4	47.7	28.0	17.8	S. 62° 33′ W.	11.5	....	....	.01	3
.183	112	52.9	31.4	13.4	44.8	N. 55° 36′ E.	38.0	0	0	0	4
.140	138	72.1	24.9	48.6	32.3	N. 19° 03′ W.	49.9	....	....	.43	5
.326	......	......	......	......	......	....	......	....	....	.01	6
.35	72	20.8	33.2	10.3	28.4	S. 55° 25′ E.	21.9	0	0	0	7
.23	136	123.8	0	18.5	21.5	N. 1° 23′ E.	124.1	0	0	0	8
.171	114	49.2	49.4	4.7	39.4	S. 89° 40′ E.	34.7	0	0	0	9
.063	122	59.3	18.4	61.4	15.2	N. 48° 29′ W.	61.7	5 p.m.	6 p.m.	.29	10
.114	......	......	......	......	......	....	......	0	0	0	11
.12	......	......	......	......	......	....	......	0	0	T	12
.087	118	95.9	10.3	33.6	6.1	N. 17° 49′ W.	89.9	0	0	0	13
.121	106	86.2	9.1	14.5	18.4	N. 2° 54′ E.	77.2	0	0	T	14
.060	133	73.6	23.5	56.0	9.5	N. 42° 52′ W.	68.3	0	0	0	15
.103	171	73.8	69.3	12.8	60.0	N. 84° 33′ E.	47.4	0	0	0	16
.019	150	89.1	24.8	47.0	30.8	N. 14° 09′ W.	66.2	0	0	0	17
.105	194	76.0	72.2	12.8	94.1	N. 87° 20′ E.	81.5	0	0	0	18
.131	152	35.1	80.5	6.7	84.3	S. 59° 40′ E.	89.9	0	0	0	19
.070	92	38.6	31.5	12.1	31.5	N. 69° 54′ E.	20.6	0	0	T	20
.210	101	82.8	4.0	19.1	17.1	N. 1° 27′ W.	78.9	0	0	T	21
.154	120	58.1	34.9	19.1	41.4	N. 43° 52′ E.	32.1	0	0	T	22
.141	132	67.3	18.5	65.5	17.3	N. 44° 39′ W.	68.5	0	0	T	23
.277	160	42.5	90.1	13.8	67.5	S. 48° 27′ E.	71.7	0	0	T	24
.230	162	16.0	106.0	4.0	94.5	S. 45° 10′ E.	127.6	0	0	T	25
.266	111	46.5	44.4	11.4	35.4	N. 85° 00′ E.	24.1	0	0	0	26
.300	145	64.6	38.7	43.3	34.8	N. 18° 10′ W.	27.2	0	0	T	27
.218	117	53.0	23.3	58.6	9.4	N. 58° 53′ W.	57.4	0	0	T	28
.174	106	78.0	6.0	25.2	21.2	N. 3° 11′ W.	72.1	5 p.m.	10 p.m.	.08	29
.171	90	38.0	26.6	22.2	24.0	N. 8° 58′ E.	11.5	5 p.m.	6 p.m.	.13	30
.119	84	61.6	3.1	29.3	12.2	N. 16° 18′ W.	60.9	0	0	0	31
749.303	3342	1646.1	959.4	698.7	934.3	....	......	....	....	0.98	......
24.171	......	......	......	......	......	....	......	....	....	......	......
....	......	......	......	......	......	....	......	....	....	......	......

MONTHLY SUMMARY OF

SEPTEMBER,

DATE.	THERMOMETERS. Temperatures. Mean of 24 h.	Extremes. Max.	Extremes. Min.	Hours of Extremes. Max.	Hours of Extremes. Min.	PSYCHROMETER. Relative Humidity. 6 A.M.	12 M.	6 P.M.	Dew-point. 6 A.M.	12 M.	6 P.M.	SUNSHINE RECORD'R. Clouds at Observ'n.	Number of Minutes. Actual.	Possible.	Per ct.
1	69.0	83	57	4 p.m.	6 a.m.	52	28	35	42	44	45	5	679	745	91
2	56.9	62	49	3 p.m.	6 a.m.	64	57	66	37	44	48	10	617	742	83
3	61.8	73	54	3 p.m.	6 a.m.	64	46	43	45	46	44	9	615	740	83
4	58.5	69	50	12 m.	3 a.m.	72	56	63	44	50	51	20	511	737	69
5	57.3	70	49	1 p.m.	6 a.m.	70	52	49	39	48	43	21	509	735	69
6	58.3	70	49	12 m.	6 a.m.	88	50	66	47	48	48	12	531	732	73
7	60.6	72	50	3 p.m.	6 a.m.	76	46	56	43	46	49	15	631	729	87
8	57.2	68	49	1 p.m.	6 a.m.	88	56	65	47	50	47	17	456	725	63
9	62.3	73	50	3 p.m.	12 n't	80	33	36	55	38	40	12	656	723	91
10	60.0	75	45	2 p.m.	5 a.m.	69	26	43	38	36	44	7	624	720	87
11	64.4	80	48	3 p.m.	3 a.m.	.....	18	31	.....	29	38	.....	691	715	97
12	61.8	74	48	2 p.m.	1 a.m.	72	33	47	44	42	48	16	588	711	83
13	64.1	81	47	2 p.m.	5 a.m.	83	23	45	47	38	45	11	552	708	78
14	65.2	84	49	4 p.m.	2 a.m.	63	61	23	42	63	36	13	636	704	90
15	67.0	84	47	3 p.m.	5 a.m.	71	15	24	42	29	34	7	638	702	91
16	68.6	83	52	2 p.m.	5 a.m.	31	15	23	27	27	33	3	666	700	95
17	66.3	79	52	4 p.m.	3 a.m.	39	14	23	34	24	30	9	635	698	91
18	48.9	57	37	5 p.m.	8 a.m.	87	49	63	42	32	50	14	499	696	72
19	51.7	70	37	3 p.m.	4 a.m.	64	19	26	29	23	27	0	639	695	92
20	58.8	82	38	3 p.m.	4 a.m.	35	13	16	22	22	22	0	672	693	97
21	62.2	77	44	3 p.m.	6 a.m.	41	12	18	26	23	26	0	669	692	97
22	63.2	78	44	3 p.m.	5 a.m.	33	20	20	26	30	28	4	638	689	93
23	61.1	77	45	3 p.m.	3 a.m.	52	15	21	31	29	20	1	646	687	94
24	61.0	78	45	3 p.m.	6 a.m.	52	24	29	31	37	36	8	635	685	93
25	63.0	79	52	2 p.m.	4 a.m.	54	17	39	45	27	42	20	550	683	81
26	56.6	67	46	2 p.m.	7 a.m.	70	40	45	41	40	39	14	516	679	76
27	59.4	75	44	3 p.m.	2 a.m.	75	23	29	40	33	34	6	610	675	90
28	63.9	77	48	3 p.m.	2 a.m.	21	26	32	24	38	33	0	642	671	95
29	59.7	78	44	2 p.m.	6 a.m.	75	23	44	39	33	42	14	501	669	75
30	52.2	67	36	4 p.m.	12 n't	33	22	35	20	24	38	0	590	664	89
Sums,	1821.0	2242	1405	....	....	1774	932	1155	1089	1093	1160	268	.....	.....	2565
Means,	60.7	74.7	46.8	....	....	61	31	38	36	36	39	9	.....	.....	.....
Perctg.	.....	.....	.....	....	....	.....	.....	.....	.....	.....	.....	30%	.....	.....	86%

INSTRUMENTAL RECORD.

1905.

Barom.	Anemometer and Anemoscope.							Rain Gauge.			
	Wind.							Hours of Fall.			
Actual Pressure at 12 M.	Total Velocity.	Sum of Components.				Equivalent.				Total Amount.	Date.
		N.	S.	W.	E.	Direction.	Miles.	Earliest.	Latest.		
24.141	92	45.6	21.3	15.1	36.8	N. 41° 46′ E.	32.5	0	0	T	1
.294	42	10.5	21.2	1.1	24.0	S. 64° 58′ E.	25.2	0	0	0	2
.207	43	3.9	27.2	0	26.4	S. 48° 34′ E.	35.2	0	0	0	3
.130	43	40.9	0	3.2	9.3	N. 8° 29′ E.	41.3	0	0	T	4
.066	44	27.5	8.3	12.2	6.6	N. 16° 16′ W.	20.0	9 p.m.	9 p.m.	.13	5
.125	44	28.8	5.7	13.5	6.6	N. 16° 38′ W.	24.1	1 a.m.	11 p.m.	.19	6
.251	42	16.2	14.4	7.5	16.6	N. 78° 49′ E.	9.2	0	0	0	7
.223	39	18.3	15.2	3.6	10.7	N. 66° 21′ E.	7.7	3 p.m.	3 p.m.	.11	8
.239	48	28.2	0	28.8	1.0	N. 44° 35′ W.	39.6	0	0	0	9
.188	21	3.0	15.2	1.2	6.3	S. 22° 41′ E.	13.2	0	0	0	10
.092	43	19.8	5.4	23.1	7.3	N. 47° 39′ W.	21.3	0	0	0	11
.193	69	38.6	21.5	7.8	20.7	N. 37° 02′ E.	21.4	0	0	0	12
.110	42	22.4	3.3	9.7	16.4	N. 19° 20′ E.	20.2	0	0	T	13
.044	46	8.6	27.5	17.1	8.2	S. 25° 13′ W.	20.8	0	0	0	14
23.994	49	9.2	22.2	22.6	5.7	S. 52° 26′ W.	21.3	0	0	0	15
.956	41	8.3	17.0	20.0	8.8	S. 52° 10′ W.	14.1	0	0	0	16
.766	48	14.2	18.9	26.1	2.1	S. 78° 55′ W.	24.4	0	0	0	17
24.054	185	160.8	14.1	31.5	15.2	N. 6° 20′ W.	147.7	7 a.m.	8 a.m.	.05	18
.229	133	65.3	57.9	0.9	32.3	N. 76° 44′ E.	32.2	0	0	0	19
.133	......	......	......	......	......	....	......	0	0	0	20
.183	......	......	......	......	......	....	......	0	0	0	21
.268	176	74.1	75.6	13.7	62.1	N. 88° 13′ E.	48.4	0	0	0	22
.267	146	60.4	64.4	2.4	55.8	S. 85° 43′ E.	53.5	0	0	0	23
.126	151	60.6	71.4	5.5	52.3	S. 77° 00′ E.	48.0	0	0	0	24
.103	......	......	......	......	......	....	......	0	0	0	25
.139	......	......	......	......	......	....	......	0	0	T	26
23.967	99	41.1	44.1	6.7	35.1	S. 83° 58′ E.	28.5	0	0	0	27
.896	136	47.1	58.0	17.7	53.9	S. 73° 15′ E.	37.8	0	0	0	28
.638	270	31.8	195.8	35.6	88.8	S. 17° 58′ E.	172.5	0	0	0	29
.911	188	50.2	51.0	53.9	85.0	S. 88° 32′ E.	31.1	0	0	0	30
722.933	2280	935.4	876.6	380.5	694.0	....	......	......	......	0.48	......
24.098	......	......	......	......	......	....	......	......	......	......	......
......	......	......	......	......	......	....	......	......	......	......	......

MONTHLY SUMMARY OF

OCTOBER,

Date.	Thermometers.					Psychrometer.						Sunshine Record'r			
	Temperatures.			Hours of Extremes.		Relative Humidity.			Dew-point.			Clouds at Observ'n.	Number of Minutes.		
	Mean of 24 h.	Extremes.													
		Max.	Min.	Max.	Min.	6 A.M.	12 M.	6 P.M.	6 A.M.	12 M.	6 P.M.		Actual.	Possible.	Per ct.
1	47.2	62	33	4 p.m.	6 a.m.	75	39	34	28	31	30	0	650	664	98
2	51.6	73	33	3 p.m.	6 a.m.	60	22	32	24	29	33	0	660	662	100
3	58.5	76	40	2 p.m.	6 a.m.	37	12	18	20	20	23	0	650	660	98
4	57.8	76	40	2 p.m.	5 a.m.	59	11	39	29	18	39	0	650	656	99
5	59.1	78	40	3 p.m.	1 a.m.	25	13	22	12	22	29	0	645	655	98
6	62.4	81	41	3 p.m.	4 a.m.	25	12	12	18	23	15	0	643	653	98
7	60.1	76	42	2 p.m.	4 a.m.	21	11	19	12	18	24	0	593	651	91
8	57.0	79	39	1 p.m.	12 n't	11	13	47	8	22	29	6	366	647	57
9	36.2	45	30	1 p.m.	12 n't	74	38	62	27	22	26	25	388	645	60
10	35.2	50	23	3 p.m.	6 a.m.	67	27	34	17	12	17	0	627	642	98
11	42.3	62	23	2 p.m.	4 a.m.	77	18	36	18	16	26	0	578	639	90
12	53.7	73	32	2 p.m.	3 a.m.	61	20	15	25	30	16	3	585	635	92
13	55.6	68	40	1 p.m.	12 n't	36	14	12	26	17	11	10	447	633	71
14	36.3	42	28	12 m.	12 n't	75	.....	67	28	.....	26	.....	412	631	65
15	40.1	56	26	4 p.m.	5 a.m.	70	38	30	21	26	21	12	476	629	76
16	45.9	68	31	2 p.m.	3 a.m.	62	21	32	26	25	18	8	524	626	84
17	35.8	42	32	6 p.m.	8 a.m.	82	76	77	30	30	33	22	.....	624	.....
18	41.9	60	31	4 p.m.	6 a.m.	81	19	50	27	16	29	2	476	620	77
19	36.8	46	28	3 p.m.	12 n't	63	34	39	22	17	16	0	562	617	91
20	34.7	50	18	3 p.m.	5 a.m.	60	19	34	10	11	17	0	601	614	98
21	35.2	46	24	3 p.m.	12 n't	59	35	52	23	19	21	0	577	612	94
22	35.2	54	19	3 p.m.	5 a.m.	73	35	37	12	22	20	0	535	608	88
23	47.6	65	32	2 p.m.	1 a.m.	68	29	29	27	29	23	7	381	606	63
24	44.4	54	31	3 p.m.	12 n't	59	34	40	29	25	25	0	542	604	90
25	46.8	67	27	3 p.m.	5 a.m.	61	20	19	20	20	16	0	561	601	93
26	54.0	68	40	3 p.m.	12 n't	27	16	38	18	19	29	14	478	597	80
27	35.6	40	33	1 a.m.	12 n't	82	74	92	30	27	33	29	0	596	0
28	31.7	38	27	3 p.m.	12 n't	90	91	83	28	31	31	27	29	595	5
29	31.4	39	26	2 p.m.	4 a.m.	89	76	75	23	30	28	29	0	592	0
30	25.0	28	23	1 a.m	8 p.m	87	89	88	22	22	21	30	0	589	0
31	31.0	48	16	2 p.m.	5 a.m.	87	39	57	17	23	27	0	542	588	92
Sums,	1366.1	1810	948	....	....	1905	995	1282	716	682	726	224	.....	.....	2246
Means,	44.1	58.4	30.6	....	....	61	33	41	23	23	23	7	.....	.....	.....
Perctg.	.....	.....	.....	....	....	.....	.....	.....	.....	.....	.....	23%	.....	.....	75%

INSTRUMENTAL RECORD.

1905.

BAROM.	ANEMOMETER AND ANEMOSCOPE.							RAIN GAUGE.			Date.
	WIND.							Hours of Fall.		Total Amount.	
Actual Pressure at 12 M.	Total Velocity.	Sum of Components.				Equivalent.		Earliest.	Latest.		
		N.	S.	W.	E.	Direction.	Miles.				
24.146	81	13.8	28.6	18.0	41.8	S. 58° 08′ E.	28.0	0	0	0	1
.189	118	13.3	35.4	36.8	64.7	S. 51° 37′ E.	35.5	0	0	0	2
.179	143	17.4	45.3	46.2	74.2	S. 45° 06′ E.	39.5	0	0	0	3
.127	140	14.3	35.5	40.5	83.5	S. 63° 45′ E.	47.9	0	0	0	4
.118	137	18.7	36.1	47.9	71.2	S. 53° 15′ E.	29.0	0	0	0	5
.093	127	9.4	33.3	39.8	72.0	S. 53° 25′ E.	40.1	0	0	0	6
.013	153	16.0	35.7	42.2	95.4	S. 69° 41′ E.	56.7	0	0	0	7
23.775	194	47.3	15.3	39.6	131.4	N. 70° 47′ E.	97.2	0	0	0	8
24.102	140	36.4	26.7	9.3	102.7	N. 84° 04′ E.	93.8	0	0	0	9
.214	77	24.2	10.6	6.9	55.9	N. 74° 29′ E.	50.8	....	....	.04	10
.241	113	14.2	33.4	35.0	61.9	S. 54° 29′ E.	33.0	0	0	0	11
23.890	136	22.4	18.9	41.9	82.1	N. 85° 01′ E.	40.3	0	0	0	12
.740	233	61.6	35.2	31.7	167.5	N. 79° 00′ E.	138.3	9 p.m.	10 p.m.	.05	13
24.020	352	21.9	25.9	1.9	343.6	S. 89° 20′ E.	342.8	....	3 a.m.	.02	14
23.949	118	5.7	49.2	53.7	46.3	S. 9° 39′ W.	44.1	0	0	0	15
.766	266	26.2	22.3	46.8	208.7	N. 88° 37′ E.	162.0	0	0	0	16
.837	114	3.4	66.1	50.0	30.2	S. 17° 32′ W.	65.7	....	11 a.m.	.18	17
.754	249	69.5	38.1	75.1	134.9	N. 62° 18′ E.	67.5	0	0	0	18
24.186	252	69.8	75.5	99.5	96.1	S. 30° 49′ W.	6.6	0	0	0	19
.197	......	......	......	......	......	....	......	0	0	0	20
.154	......	......	......	......	......	....	......	0	0	0	21
.089	......	......	......	......	......	....	......	0	0	0	22
23.869	168	31.3	31.8	1.7	141.9	S. 89° 48′ E.	140.2	0	0	T	23
24.130	225	15.3	46.1	3.0	211.8	S. 81° 37′ E.	211.2	0	0	0	24
.158	......	......	......	......	......	....	......	0	0	0	25
.055	164	29.1	69.2	70.6	43.2	S. 34° 21′ W.	48.5	0	0	0	26
.136	199	0	138.1	139.9	0.5	S. 45° 16′ W.	196.2	0	0	T	27
.242	116	1.7	74.3	63.6	16.5	S. 32° 59′ W.	86.5	11 a.m.	1 p.m.	.08	28
.079	203	25.6	28.0	19.1	161.6	S. 89° 02′ E.	142.6	0	0	0	29
.164	......	......	......	......	......	....	......	0	0	T	30
.203	......	......	......	......	......	....	......	....	....	.09	31
745.815	4218	608.3	1054.6	1060.7	2539.6	....	......	....	....	0.46	......
24.059	......	......	......	......	......	....	......	....	....	......	......
....	......	......	......	......	......	....	......	....	....	......	......

MONTHLY SUMMARY OF

November,

Date.	Thermometers.					Psychrometer.						Sunshine Record'r			
	Temperatures.			Hours of Extremes.		Relative Humidity.			Dew-point.			Clouds at Observ'n.	Number of Minutes.		
	Mean of 24 h.	Extremes. Max.	Min.	Max.	Min.	6 A.M.	12 M.	6 P.M.	6 A.M.	12 M.	6 P.M.		Actual.	Possible.	Per ct.
1	40.4	55	22	3 p.m.	7 a.m.	75	37	55	17	25	30	3	480	586	82
2	50.7	65	29	2 p.m.	12 n't	46	15	44	32	16	25	0	550	582	95
3	40.5	58	25	3 p.m.	6 a.m.	79	42	51	22	30	30	0	530	579	92
4	43.9	56	36	11 a.m.	6 a.m.	64	46	61	29	32	31	21	45	578	8
5	34.9	39	27	2 p.m.	12 n't	67	62	69	26	26	28	16	5	576	1
6	40.8	61	24	2 p.m.	4 a.m.	59	25	42	17	24	28	1	499	574	87
7	38.5	55	26	2 p.m.	4 a.m.	61	34	43	20	25	23	1	507	572	89
8	40.2	50	28	1 p.m.	1 a.m.	68	42	64	27	28	29	17	236	570	41
9	35.4	47	24	2 p.m.	12 n't	81	43	60	27	23	24	3	390	568	69
10	35.5	53	21	2 p.m.	3 a.m.	73	26	45	14	20	22	0	508	566	90
11	40.4	60	22	2 p.m.	2 a.m.	70	14	28	21	10	16	2	470	565	83
12	44.8	58	32	3 p.m.	7 a.m.	75	19	17	29	16	7	0	511	563	91
13	45.8	61	33	2 p.m.	5 a.m.	67	23	31	26	22	20	0	532	561	95
14	50.8	70	29	3 p.m.	5 a.m.	67	19	19	26	23	20	0	514	559	92
15	44.4	58	30	3 p.m.	8 a.m.	75	39	35	28	39	22	0	500	558	90
16	47.2	66	30	3 p.m.	2 a.m.	66	20	36	25	22	26	0	437	556	79
17	47.1	57	37	3 p.m.	7 a.m.	62	33	38	26	26	26	21	143	554	26
18	41.8	58	30	3 p.m.	6 a.m.	60	27	63	24	23	35	5	374	552	68
19	39.3	52	22	3 p.m.	6 a.m.	77	30	51	18	21	25	0	486	551	88
20	42.5	60	28	2 p.m.	1 a.m.	69	23	36	28	18	23	3	466	549	85
21	38.1	51	25	3 p.m.	6 a.m.	78	47	58	21	29	28	14	288	548	53
22	38.5	40	34	4 p.m.	7 a.m.	92	92	85	36	37	35	30	5	547	1
23	41.6	48	34	1 p.m.	8 a.m.	84	15	8	32	4	–7	10	489	545	90
24	42.4	55	26	4 p.m.	8 a.m.	64	32	23	23	18	14	0	486	543	89
25	48.8	60	34	3 p.m.	3 a.m.	61	10	28	31	4	20	0	507	541	94
26	48.5	59	36	3 p.m.	8 a.m.	59	20	22	29	16	38	6	353	540	65
27	45.2	58	34	12 m.	12 n't	65	34	37	30	17	20	7	409	539	76
28	30.0	36	24	2 a.m.	12 n't	61	73	68	20	26	19	6	477	538	89
29	18.2	27	9	3 p.m.	8 a.m.	62	35	72	0	0	11	0	400	537	74
30	22.0	37	6	4 p.m.	6 a.m.	86	32	66	3	6	25	0	463	536	86
Sums,	1218.2	1610	817	....	....	2073	1009	1435	707	626	693	166	.....	.....	2168
Means,	40.6	53.7	27.2	....	....	69	34	48	24	21	23	6	.....	.....	.....
Perctg.	......	.....	.....	....	....	.....	.....	.....	.....	.....	.....	20%	.....	.....	72%

INSTRUMENTAL RECORD.

1905.

BAROM.	ANEMOMETER AND ANEMOSCOPE.							RAIN GAUGE.			Date.
Actual Pressure at 12 M.	WIND.							Hours of Fall.		Total Amount.	
	Total Velocity.	Sum of Components.				Equivalent.		Earliest.	Latest.		
		N.	S.	W.	E.	Direction.	Miles.				
24.065	155	60.4	22.5	19.3	97.7	N. 64° 12′ E.	87.0	0	0	0	1
23.969	351	203.3	67.3	78.1	124.7	N. 18° 55′ E.	143.8	0	0	0	2
.969	124	18.8	34.9	31.1	72.8	S. 68° 53′ E.	44.6	0	0	0	3
.755	242	47.9	18.9	1.5	225.0	N. 82° 36′ E.	225.3	0	0	0	4
24.217	198	20.6	44.6	20.8	159.8	S. 80° 12′ E.	141.0	0	0	0	5
.079	161	80.1	15.5	8.8	107.9	N. 56° 54′ E.	118.1	0	0	0	6
.135	137	10.7	45.9	43.2	73.6	S. 40° 48′ E.	46.5	0	0	0	7
.041	295	78.1	9.8	0	272.2	N. 75° 55′ E.	280.7	0	0	0	8
.258	140	15.2	28.3	34.7	94.7	S. 77° 41′ E.	61.4	0	0	0	9
.249	116	6.7	27.6	32.2	71.7	S. 62° 07′ E.	44.6	0	0	0	10
.232	149	16.1	21.7	9.4	128.2	S. 87° 18′ E.	118.9	0	0	0	11
.279	245	15.3	21.1	0	239.4	S. 88° 37′ E.	239.8	0	0	0	12
.245	242	33.5	4.7	0	234.8	N. 83° 00′ E.	236.4	0	0	0	13
.070	177	63.0	17.7	30.3	111.4	N. 60° 49′ E.	92.9	0	0	0	14
.075	147	18.7	37.0	34.5	92.5	S. 72° 29′ E.	60.8	0	0	0	15
23.965	137	22.3	18.0	19.8	104.0	N. 87° 05′ E.	84.4	0	0	0	16
.981	141	9.9	37.9	61.2	63.8	S. 5° 18′ E.	28.1	0	0	0	17
.984	137	7.8	26.8	20.8	104.4	S. 77° 12′ E.	85.7	0	0	T	18
24.099	168	15.0	52.3	59.3	83.8	S. 33° 18′ E.	44.6	0	0	0	19
23.853	110	8.4	29.7	41.0	56.9	S. 36° 45′ E.	26.5	0	0	0	20
24.107	114	7.3	26.3	5.7	92.5	S. 77° 39′ E.	88.8	0	0	0	21
.032	199	5.1	127.9	145.8	0	S. 49° 54′ W.	190.6	....	8 p.m.	.23	22
23.717	434	295.1	39.4	32.2	220.1	N. 36° 19′ E.	317.3	0	0	0	23
.968	253	161.6	30.0	52.3	86.1	N. 14° 24′ E.	135.9	0	0	0	24
.806	310	109.9	86.7	96.3	118.6	N. 43° 52′ E.	32.1	0	0	0	25
.860	121	31.9	33.4	53.0	39.2	S. 83° 48′ W.	13.8	0	0	0	26
.398	274	153.5	33.6	125.6	20.2	N. 41° 20′ W.	159.6	0	0	T	27
.660	419	350.5	2.0	12.5	198.7	N. 28° 07′ E.	395.1	0	0	T	28
24.210	196	71.0	67.2	78.1	45.5	N. 83° 21′ W.	32.8	0	0	0	29
23.814	119	22.8	35.2	23.3	67.3	S. 74° 16′ E.	45.7	0	0	0	30
720.092	6011	1960.5	1093.9	1170.8	3407.5	....	......	....	....	0.23	......
24.003	......	......	....	......	......	....	......	....	....	......	......
....	......	......	....	......	......	....	......	....	....	......	......

MONTHLY SUMMARY OF

DECEMBER,

DATE.	THERMOMETERS. Temperatures. Mean of 24 h.	Extremes. Max.	Extremes. Min.	Hours of Extremes. Max.	Hours of Extremes. Min.	PSYCHROMETER. Relative Humidity. 6 A.M.	Relative Humidity. 12 M.	Relative Humidity. 6 P.M.	Dew-point. 6 A.M.	Dew-point. 12 M.	Dew-point. 6 P.M.	SUNSHINE RECORD'R. Clouds at Observ'n.	Number of Minutes. Actual.	Number of Minutes. Possible.	Per ct.
1	26.2	37	17	1 p.m.	7 a.m.	60	83	59	10	31	17	11	313	535	59
2	19.8	30	8	3 p.m.	12 n't	90	66	60	12	16	10	6	369	535	69
3	23.5	42	6	3 p.m.	4 a.m.	62	44	72	0	21	24	0	450	533	84
4	32.0	47	17	3 p.m.	4 a.m.	75	45	59	16	22	23	12	260	533	49
5	29.0	47	16	3 p.m.	7 a.m.	73	66	44	12	31	14	2	469	532	88
6	34.5	60	17	2 p.m.	1 a.m.	45	31	46	8	27	15	0	482	532	91
7	33.9	54	16	2 p.m.	5 a.m.	75	17	29	16	14	9	4	483	530	91
8	35.6	49	26	12 m.	12 n't	26	26	48	9	14	17	19	67	530	13
9	25.2	35	13	3 p.m.	12 n't	17	72	65	18	25	15	0	451	528	85
10	23.9	45	7	4 p.m.	7 a.m.	81	13	56	6	–1	14	0	477	528	90
11	34.4	55	14	2 p.m.	1 a.m.	54	5	46	11	–9	15	1	373	528	71
12	28.6	42	16	12 m.	12 n't	73	32	60	14	15	18	1	378	528	72
13	29.1	49	12	3 p.m.	6 a.m.	85	21	43	13	9	12	0	461	526	88
14	34.6	51	19	3 p.m.	3 a.m.	50	12	43	14	3	16	0	355	526	67
15	32.0	52	16	4 p.m.	6 a.m.	59	20	48	8	13	17	0	459	526	87
16	41.9	57	26	3 p.m.	1 a.m.	55	21	17	12	12	11	17	149	526	28
17	33.6	48	21	1 a.m.	7 a.m.	43	17	43	6	4	12	1	388	525	74
18	24.2	37	13	3 p.m.	6 a.m.	84	67	59	12	26	17	1	340	525	65
19	31.1	46	16	2 p.m.	1 a.m.	52	21	29	10	9	6	7	366	525	70
20	29.4	40	20	1 p.m.	12 n't	52	40	52	16	18	16	11	131	525	25
21	21.9	30	13	1 p.m.	5 a.m.	58	49	52	7	13	10	1	375	524	72
22	18.7	25	6	3 p.m.	12 n't	84	41	72	12	5	14	14	389	524	74
23	17.9	32	5	3 p.m.	1 a.m.	41	38	37	8	7	2	0	427	525	81
24	24.2	39	14	3 p.m.	11 p.m.	72	22	35	11	4	0	9	205	525	39
25	30.0	48	10	2 p.m.	5 a.m.	63	10	28	2	–2	2	0	471	525	90
26	32.5	42	21	1 a.m.	7 a.m.	43	27	29	6	7	6	19	0	525	0
27	26.2	35	13	4 p.m.	8 a.m.	9	53	52	–22	18	16	1	448	526	85
28	20.6	26	8	2 a.m.	12 n't	60	45	72	10	8	11	5	122	526	23
29	18.7	30	4	1 p.m.	5 a.m.	62	43	29	0	12	–2	21	125	527	24
30	16.9	29	3	4 p.m.	8 a.m.	79	51	63	3	8	12	5	434	527	82
31	27.2	44	10	2 p.m.	1 a.m.	56	25	35	5	10	9	7	343	528	65
Sums,	857.3	1303	423	....	....	1839	1182	1482	309	389	382	175	.....	.....	2001
Means,	27.7	42.0	13.6	....	....	59	38	48	9	13	12	6	.....	.....	.....
Perctg.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	20%	.....	.....	65%

INSTRUMENTAL RECORD.

1905.

BAROM.	ANEMOMETER AND ANEMOSCOPE.							RAIN GAUGE.			Date.
	WIND.							Hours of Fall.		Total Amount.	
Actual Pressure at 12 M.	Total Velocity.	Sum of Components.				Equivalent.		Earliest.	Latest.		
		N.	S.	W.	E.	Direction.	Miles.				
23.924	199	81.2	6.0	2.9	166.3	N. 65° 17′ E.	179.9	0	0	0	1
24.141	......	......	......	......	......	....	......	0	0	0	2
.209	129	23.8	22.7	21.9	94.4	N. 89° 08′ E.	72.6	0	0	0	3
.161	123	19.2	21.4	14.5	95.7	S. 88° 27′ E.	81.3	0	0	0	4
.304	130	15.1	18.2	17.7	102.0	S. 87° 54′ E.	84.4	0	0	0	5
.268	164	16.1	15.9	19.2	134.7	N. 89° 54′ E.	115.5	0	0	0	6
.135	123	3.5	17.8	13.6	100.9	S. 80° 42′ E.	88.4	0	0	0	7
.104	237	69.6	27.0	10.7	189.0	N. 76° 34′ E.	183.4	0	0	0	8
.477	201	28.0	25.6	19.6	164.6	N. 89° 03′ E.	145.1	0	0	T	9
.318	144	9.8	14.0	15.5	120.0	S. 87° 42′ E.	104.6	0	0	0	10
.032	170	13.4	19.2	18.8	141.0	S. 87° 17′ E.	122.4	0	0	0	11
23.983	133	9.8	35.6	36.1	81.0	S. 60° 07′ E.	51.7	0	0	0	12
24.075	138	6.6	16.8	23.8	108.5	S. 83° 08′ E.	85.3	0	0	0	13
.091	178	12.3	25.4	0	171.0	S. 85° 37′ E.	171.5	0	0	0	14
.135	126	......	......	......	......	....	......	0	0	0	15
23.955	178	......	......	......	......	....	......	0	0	0	16
.984	96	......	......	......	......	....	......	0	0	0	17
.887	105	......	......	......	......	....	......	0	0	0	18
.790	120	......	......	......	......	....	......	0	0	0	19
.744	126	......	......	......	......	....	......	0	0	0	20
.877	173	169.2	0	14.1	12.5	N. 0° 33′ W.	169.2	0	0	0	21
24.123	152	146.3	0	11.5	19.7	N. 3° 12′ E.	146.7	0	0	0	22
.235	97	73.8	14.1	13.7	14.4	N. 0° 40′ E.	59.9	0	0	0	23
.232	96	77.6	12.1	3.9	14.1	N. 8° 51′ E.	66.3	0	0	0	24
.090	138	103.0	22.9	19.8	19.1	N. 0° 30′ W.	80.2	0	0	0	25
23.726	71	32.9	17.6	16.6	19.1	N. 9° 17′ E.	15.5	0	0	0	26
.748	182	102.7	39.8	55.2	36.2	N. 16° 49′ W.	65.7	0	0	0	27
.859	251	220.5	0	80.2	20.8	N. 15° 05′ W.	228.3	0	0	0	28
.835	128	98.7	12.4	22.7	21.6	N. 0° 44′ W.	86.3	0	0	0	29
.957	127	68.4	40.1	10.8	41.3	N. 47° 07′ E.	41.6	0	0	0	30
.692	142	112.4	6.4	16.9	28.8	N. 6° 24′ E.	106.7	0	0	0	31
745.091	4377	1513.9	431.0	479.7	1916.7	....	......	....	....	T	......
24.035	......	......	......	......	......	....	......	....	....	....	......
....	......	......	......	......	......	....	......	....	....	....	......

ANNUAL SUMMARY, BY MONTHS.

MONTH.	BAROMETER.					THERMOMETER.							ANEMOMETER.		
	Mean at 12 M.	Extremes.		Dates of Extremes.		Mean.	Extremes.		Dates of Extremes.		Mean Max.	Mean Min.	Wind		
		Max.	Min.	Max.	Min.		Max.	Min.	Max.	Min.			Mean Daily Velocity	Max. Daily Velocity	Date.
January	24.075	24.42[1]	23.80	14	11	28.3	58	7	3	13	41.2	16.4	170	319	23
February	.005	.34	.60	21	8	21.4	59	22[2]	20	12	33.7	9.8	169	490	8
March	23.951	.28	.48	2	27	39.9	67	19	26	28	51.0	30.5	235	500[1]	27
April	.954	.18	.72	4	19	41.9	73	21	30	4	52.4	30.9	213	393	19
May	.928	.24	.51	30	3	51.5	76	29	31	5	63.1	41.0	223	381	9
June	24.027	.18	.91	11	22	64.8	90[1]	44	27	6	77.0	50.4	198	324	25
July	.142	.30	.90	8	1	64.7	88	41	17	8	77.9	51.7	146	275	8
August	.171	.35	24.02	7	17	67.3	90[1]	47	21	7	81.0	53.5	124	194	18
September	.098	.29	23.64	2	29	60.7	84	36	14[3]	30	74.7	46.8	88	270	29
October	.059	.24	.74	28	13	44.1	81	16	6	31	58.4	30.6	169	352	14
November	.003	.28	.10[2]	12	27	40.6	70	6	14	30	53.7	27.2	200	434	23
December	.035	.48	.69	9	31	27.7	60	3	6	30	42.0	13.6	146	251	28
	288.448	291.58	284.41	......	......	552.9	......	......	......	......	706.1	402.4	2,081	......	......
	24.037	24.30	23.70	......	......	46.1	......	......	......	......	58.8	33.5	173	......	......

MONTH.	PSYCHROMETER.								PERCENTAGES OF CLOUD AND SUN.		RAIN GAUGE.		NUMBER OF DAYS.						
	Relative Humidity.			Minimum Humidity.[5]		Dew-point.			Cloud (Area)	Sunshine (Time)	Total Rain.	Max. in Day.	Max. below 32	Min below 32	Max. above 80	Clear.	Part Cloudy	Cloudy	Rain.[4]
	6 A.M.	12 M.	6 P.M.	Per ct.	Date.	6 A.M.	12 M.	6 P.M.											
Jan.	67	46	55	10	14	14	13	15	40	66	0.17	0.14	6	28	0	14	11	6	4
Feb.	63	48	58	10	24	6	10	12	40	75	1.11	0.60	13	28	0	13	10	5	7
Mar.	68	49	63	16	4	25	26	30	57	60	2.41	0.66	1	16	0	9	11	11	7
April	67	51	53	10	7	25	26	27	50	53	4.46	2.35[1]	1	17	0	10	11	9	7
May	64	38	47	16	8	34	31	34	47	72	2.38	0.60	0	1	0	9	16	6	9
June	65	36	36	9	24	46	41	41	40	75	0.81	0.44	0	0	9	13	13	4	5
July	66	34	45	16	6	46	43	46	43	75	2.38	0.57	0	0	11	10	18	3	12
Aug	62	31	41	11	21	46	43	46	37	83	0.98	0.43	0	0	16	16	15	0	8
Sept	61	31	38	12	21	38	36	39	30	86	0.48	0.19	0	0	6	16	14	0	4
Oct	61	33	41	11	4[3]	23	23	23	23	75	0.46	0.18	1	17	1	22	3	6	6
Nov.	69	34	48	8	23[6]	24	21	23	20	72	0.23	0.23	1	21	0	23	6	1	1
Dec.	59	38	48	5	11	9	13	12	20	65	T	T	6	31	0	23	8	0	0
	772	469	573	......	......	336	326	348	447	857	15.90	......	29	159	43	178	136	51	70
	64	39	48	......	......	28	27	29	37	71	......	......	......	......	......	......	......	......	......

[1] Yearly maximum. [2] Yearly minimum. [3] More than one date. [4] One-hundredth of an inch or more. [5] Recorded at the noon observation, unless otherwise noted.
[6] At the 6 P. M. observation.

MEAN DAILY MARCH OF ATMOSPHERIC CONDITIONS.

Hour Ending.	January.			April.			July.			October.		
	Sun.	Barom.	Therm.	Sun.	Barom.	Therm.	Sun.	Barom.	Therm.	Sun.	Barom.	Therm.
1 A. M.	....	24.072	23.1	....	23.955	37.0	....	24.131	57.9	....	24.079	36.2
2 "	....	.074	22.9	....	.948	36.6	....	.130	56.8	....	.076	35.8
3 "	....	.071	23.0	....	.946	35.8	....	.128	55.5	....	.069	35.7
4 "	....	.063	22.9	....	.945	35.2	....	.129	54.8	....	.068	35.4
5 "	....	.058	22.8	....	.945	34.9	....	.135	54.0	....	.070	35.3
6 "	....	.062	22.5	3.2	.952	35.0	23.8	.141	55.0	....	.072	35.3
7 "	0.3	.068	22.4	11.3	.958	36.3	47.9	.142	58.4	6.7	.075	36.4
8 "	6.9	.079	22.7	22.9	.957	38.3	52.8	.142	62.9	40.9	.080	41.0
9 "	33.8	.086	26.4	39.2	.959	41.3	57.0	.138	66.2	45.7	.077	45.9
10 "	42.6	.093	30.2	44.8	.958	43.8	58.5	.133	68.9	48.6	.067	49.4
11 "	47.8	.087	33.4	42.0	.954	45.3	59.3	.129	71.2	48.0	.058	51.6
12 M.	48.9	.069	35.0	40.2	.945	46.4	56.6	.118	72.8	49.5	.043	53.5
1 P. M.	50.3	.050	36.0	44.5	.936	47.2	55.9	.106	73.5	49.1	.025	55.2
2 "	46.0	.044	36.8	41.0	.926	48.3	51.0	.097	73.5	48.9	.014	55.9
3 "	41.9	.046	36.9	40.7	.917	49.1	48.0	.098	73.2	44.3	.013	55.8
4 "	34.8	.052	36.4	35.3	.915	49.2	45.5	.097	72.6	39.9	.018	54.9
5 "	9.7	.062	34.0	25.8	.919	48.6	34.5	.098	71.5	26.8	.030	52.9
6 "	....	.072	31.2	16.8	.926	47.4	27.1	.103	70.2	6.9	.048	49.9
7 "	....	.082	28.7	1.1	.938	45.6	21.9	.110	68.6	....	.064	46.4
8 "	....	.091	26.2	....	.950	43.5	0.3	.121	66.4	....	.076	43.1
9 "	....	.094	25.5	....	.959	41.9	....	.133	64.3	....	.085	40.5
10 "	....	.093	24.4	....	.959	40.3	....	.137	62.5	....	.086	38.7
11 "	....	.092	23.5	....	.960	39.0	....	.139	60.8	....	.083	37.5
12 "	....	.087	22.9	....	.960	38.1	....	.140	59.7	....	.080	36.3
Sums,	363.0	577.747	669.8	408.8	574.687	1004.1	640.1	578.975	1551.2	455.3	577.456	1058.6
Means,	....	24.073	27.9	......	23.945	41.8	......	24.124	64.6	......	24.061	44.1

COLORADO SPRINGS WEATHER RECORDS BETWEEN 1872 AND 1903.

By Chester M. Angell.

(*Note by the Director.*) In compiling the data presented in the following tables, Mr. Angell expended a considerable amount of labor, bringing together all the records accessible to him. For many, the original sources are preserved at the Observatory; a large number of others were obtained by the kind permission of Mr. F. H. Brandenberg, District Forecaster of the U. S. Weather Bureau, from the archives of the Denver office. The oldest (1872 and 1873) though of earlier date than the foundation of the College, are due, like most of those of succeeding years, to its own observers, being the work of Messrs. E. S. Nettleton and Edward Copley, the former of whom was afterward a Trustee of the College, and still later State Engineer for Colorado.

An assemblage of very diverse material, this record of sundry parts of an interval extending over thirty-two years demands further editing and annotation before receiving its final and accepted form. In advance of special examination which may be bestowed upon certain parts of it, it has been deemed best—in view of numerous demands for historical information—to publish the whole from Mr. Angell's MS.; but with the distinct proviso that the present publication is merely preliminary, and subject to later revision. It has been prepared for the press by Mr. C. D. Child.

F. H. L.

MEAN MONTHLY TEMPERATURE.

	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEP.	OCT.	NOV.	DEC.
Year	Temp.	Temp.	Temp.	Temp.	Temp.	Temp.	Temp.	Temp.	Temp.	Temp.	Temp.	Temp.
1872	24	33	35	47	58	65	68	68	57	48	31	26
1873	27	29	42	41	53	67	69	67	59	45	41	27
1874	31	26	34	39	58	68	72	71	57	51	39	28
1875	19	29	29	42	56	66	65	66	59	52	38	36
1876	29	35	34	46	54	62	72	...	...	...	...	...
1877	...	...	...	...	...	...	...	...	...	...	32	28
1878	24	33	...	47	53	60	70	70	57	47	39	18
1879	22	33	44	...	...	...	...	...	...	...	...	...
1880	31	25	...	...	...	...	...	...	...	...	...	...
1881	...	...	...	...	...	...	...	...	...	...	...	...
1882	26	33	38	...	...	...	...	...	...	...	...	...
1883	22	23	40	44	52	...	66	66	57	44	38	31
1884	28	26	36	41	50	63	...	64	...	51	36	...
1885	25	30	39	47	52	...	...	...	...	...	40	...
1886	22	36	34	45	59	64	70	69	59	51	33	34
1887	29.9	34	43.4	46.7	57.5	67	67.5	66.4	61.5	48.1	39	28
1888	27	36	35	51	53	65	72	65	61.5	49	37	35
1889	25	28	41	49	53	62	70	71	58	50	32	41
1890	28	32	39	47	55	65	72	67	60	49	40	38
1891	27	33	...	...	...	...	...	66	62	...	...	...
1892	28	33	32	44	51	62	67	66	64	48	40.6	25.4
1893	34.9	28.9	36.4	42.7	51.6	64	68.4	64.1	60	48	36.0	34
1894	28.1	23	37	46	56	62	67	65	58	49	41.6	29.9
1895	27.8	24.6	34.4	46.4	52.1	59.7	63.4	65.4	62.2	47.0	35.1	29.5
1896	35.0	32.9	34.4	48.0	56.2	64.7	68.4	67.0	57.7	47.5	34.0	37
1897	25.4	28.8	34.6	44.2	55.8	62.1	66.4	65.4	62.4	48.5	40.2	27.7
1898	26.3	34.7	33.7	46.6	50.5	62.1	67.2	68.0	58.7	45.1	34.2	25.0
1899	26.6	16.8	33.7	47.9	54.4	63.2	66.5	68.8	62.9	49.2	42.2	31.6
1900	33.2	29.2	40.5	41.0	55.5	65.4	66.8	67.6	59.4	52.2	40.6	33.2
1901	33.1	27.0	36.3	43.5	53.8	64.2	70.8	67.6	58.8	51.0	42.4	32.2
1902	27.6	34.1	34.8	46.6	57.0	64.7	65.8	68.0	57.4	50.2	38.0	32.6
1903	32.4	20.6	36.7	45.6	52.2	57.8	68.6	65.8	58.1	50.8	40.4	34.0

MAXIMUM DAILY TEMPERATURE

For the Months—With Date.

Year.	Jan. Temp.	Jan. Date.	Feb. Temp.	Feb. Date.	March. Temp.	March. Date.	April. Temp.	April. Date.	May. Temp.	May. Date.	June. Temp.	June. Date.	July. Temp.	July. Date.	August. Temp.	August. Date.	Sept. Temp.	Sept. Date.	Oct. Temp.	Oct. Date.	Nov. Temp.	Nov. Date.	Dec. Temp.	Dec. Date.
1872	59	....	69	....	69	....	76	....	86	....	88	....	85	....	86	....	81	....	78	....	66	....	61	....
1873	57	....	58	....	69	....	77	....	77	....	88	....	90	....	85	....	81	....	83	....	70	....	65	30
1874	63	17	59	10	61	9	82	29	92	22	101	7	98	11	93	15	87	1	76	10	65	13	59	1
1875	60	20	58	27	67	29	71	....	84	6	91	27	90	....	93	....	88	....	82	....	74	....	67	....
1876	62	....	64	....	65	....	79	....	84	....	93	....	95	....	....	....	....	....	....	....	....	....	....	....
1877	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	70	....	69	....
1878	59	....	61	....	71	....	72	....	80	....	84	....	90	....	92	....	82	....	79	....	66	....	59	....
1879	68	....	69	....	77	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1880	63	....	61	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1881	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	57	....	....	....
1882	63	....	60	....	70	....	73	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1883	55	....	69	....	67	....	71	....	81	....	....	....	91	1	87	29,30	82	1	71	1	68	30	62	1
1884	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1885	....	....	....	....	....	....	71	10	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1886	30	....	39	....	50	....	80	....	83	....	85	....	93	....	89	....	84	....	77	....	66	....	61	....
1887	67	....	66	....	72	....	78	....	83	....	89	....	90	....	90	....	84	....	82	....	71	....	56	....
1888	63	....	64	....	73	....	80	....	77	14	95	....	96	....	91	....	87	....	75	....	69	....	63	....
1889	55	....	56	....	68	....	76	....	79	....	91	....	96	....	94	....	90	....	81	....	62	....	68	....
1890	73	....	77	....	70	....	74	....	85	....	92	....	94	....	96	....	86	....	74	....	74	....	70	9,10
1891	62	13	71	23	71	16	....	29	76	7, 8	....	....	....	....	94	13	....	....	....	....	....	....	....	....
1892	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	76	12	65	1
1893	66	4	59	5	75	30	72	4	82	17	93	20	93	4	86	26	84	12	76	8	67	1	58	13
1894	65	15	53	16	70	12	75	26	80	14	90	30	88	26	85	7	82	....	76	....	71	14	69	20
1895	58	13	62	23	73	28	72	28	85	8	84	23	86	26	89	16	89	11	74	1	70	17	66	13
1896	64	5	64	26	71	25	74	25	83	27	89	10	88	13	91	15	86	15	76	1	72	16	66	22
1897	58	8	58	27	64	27	73	18	80	31	89	20	91	13	89	31	87	1	78	6	73	19	64	8
1898	65	3	65	16	63	8	76	26	78	30	92	30	90	27	89	30	86	2	79	1	72	19	62	28
1899	54	21	57	19	68	24	79	23	81	14	91	19	90	5, 31	92	28	93	4	82	1	69	29	61	25
1900	62	23	59	22	73	10	67	2	80	31	90	27	92	14	90	2	89	9	79	4	70	12	60	20
1901	62	14	61	16	72	2	76	30	76	1	92	29	91	9	87	1	83	21	79	1	67	16	69	23
1902	65	13	64	12	64	9	77	30	79	31	94	24	91	15,30	98	2	89	7	75	21	71	9	64	9
1903	63	6	50	10	66	12,31	71	26	74	16	89	29	88	21,22	92	3	86	6	81	10	71	27	60	2

MINIMUM DAILY TEMPERATURE

FOR THE MONTHS—WITH DATE.

Year.	Jan. Temp.	Jan. Date.	Feb. Temp.	Feb. Date.	March. Temp.	March. Date.	April. Temp.	April. Date.	May. Temp.	May. Date.	June. Temp.	June. Date.	July. Temp.	July. Date.	August. Temp.	August. Date.	Sept. Temp.	Sept. Date.	Oct. Temp.	Oct. Date.	Nov. Temp.	Nov. Date.	Dec. Temp.	Dec. Date.
1872	–20	....	0	....	5	....	22	....	34	....	46	....	48	....	49	....	31	....	15	....	7	....	–14	....
1873	–21	....	6	....	9	....	14	....	33	....	51	....	49	....	54	....	34	....	10	....	7	....	–9	6
1874	–15	23	–17	25	1	11	5	23	27	4	39	12	48	3	52	31	27	19	20	29	4	19	–4	18
1875	–25	13	–8	3	–4	19	6	8	26	3	32	2	47	....	42	....	27	....	18	....	9	....	3	....
1876	–2	....	–1	....	3	....	7	....	26	....	37	....	45	....	....	....	....	....	....	....	....	....	....	....
1877	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	–9	....	–2	....
1878	–5	....	7	....	13	....	20	....	30	....	42	....	49	....	50	....	33	....	13	....	5	....	–15	....
1879	–18	....	–9	....	12	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1880	–15	....	–21	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1881	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	–8	....	....	....
1882	–14	....	3	....	–9	....	15	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1883	–32	....	–26	....	6	....	19	....	26	....	....	....	46	8, 9	44	23	31	20	19	25	15	15	1	30
1884	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1885	....	....	....	....	....	....	18	22	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1886	–33	....	–30	....	–9	....	–15	....	36	....	45	....	44	....	45	....	28	....	22	....	....	....	1	....
1887	–10	....	–2	....	7	....	12	....	29	....	43	....	48	....	45	....	36	....	9	....	16	....	–14	....
1888	–23	....	10	....	1	....	27	....	31	1	38	....	47	....	45	....	37	....	22	....	12	....	7	....
1889	–4	....	–8	....	18	....	26	....	31	....	36	....	45	....	47	....	28	....	23	....	6	....	5	....
1890	–5	....	–12	....	–2	....	16	....	30	....	38	....	50	....	44	....	32	....	22	....	15	....	8	8
1891	2	10	–3	9	0	7	11	2, 3	28	21	....	....	....	....	40	23	....	....	....	....	....	....	....	....
1892	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	12	3	–8	21
1893	6	15	3	2	6	14	6	14	25	1	34	6	47	19	42	30	35	25	14	26	2	23	2	30
1894	10	6	–6	4	6	22	17	9	29	1	42	10	48	21	43	27	28	....	17	....	11	23	–8	27
1895	10	28	–19	12	–6	14	12	2	30	17	34	5	44	10	45	25	26	23	18	27	3	26	1	29
1896	–3	3	4	5	–3	4	9	1	31	1	40	1	50	1	44	23	31	27	24	31	–10	27	15	18
1897	–18	27	–4	14	6	13	18	1	36	1	36	3	40	20	45	22	37	16	22	28	11	29	–1	17
1898	–6	26	12	20	–5	23	20	2	28	2, 4	40	4	50	21	46	3	30	11	18	25	2	22	17	9
1899	–8	31	–24	12	–3	28	15	6	23	3	39	3	46	4	46	20	30	28	26	18	16	2	6	15
1900	–2	29	–8	17	12	16	8	11	34	1	44	5	47	20	45	25	32	28	14	31	12	25	–16	31
1901	–19	1	8	5	2	30	12	17	34	7	41	16	51	6	48	29	27	19	25	13	18	12,19	13	14
1902	16	26	–8	2	6	30	15	15	36	22	40	18	40	6	48	6	27	12	28	28	5	29	0	4
1903	4	11	–12	16	–2	1	18	13	28	2,3	37	1	37	4	42	29	26	17	20	31	–5	18	7	12

MEAN OF MAXIMUM AND MINIMUM DAILY TEMPERATURES

For the Months.

Year.	Jan.		Feb.		March.		April.		May.		June.		July.		August.		Sept.		Oct.		Nov.		Dec.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1874	47	15	40	12	48	20	54	23	75	42	86	51	89	55	85	55	71	42	63	39	53	24	42	15
1875	35	3	41	16	42	17	.....	28	70	42	82	50	76	53	80	52	74	45	69	36	52	24	52	21
1876	45	12	52	18	49	18	61	31	68	40	72	47	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1877	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1878	.....	.....	47	20	.....	.....	60	34	65	41	71	49	83	57	81	58	70	43	62	32	51	26	31	6
1879	38	7	47	20	59	29	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1880	46	16	39	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1881	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	38	.....	.....	.....
1882	41	11	48	17	51	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1883	37	7	.....	5	55	24	57	31	66	38	.....	.....	80	55	79	54	71	42	56	33	54	25	44	18
1884	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1885	.....	.....	.....	.....	.....	.....	60	33	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1886	.....	.....	.....	.....	.....	.....	56	32	75	43	76	50	85	55	82	56	73	45	65	37	46	21	48	20
1887	43	16	46	17	58	28	58	32	70	43	80	51	80.7	54.3	79.2	53.5	74	49.0	61.7	34.5	54.3	24	41.7	14.9
1888	42.7	10.6	48.9	24	51.3	19.4	65.8	36.9	65.4	39.9	82.3	49.5	86.9	56.6	79.2	51.9	76.5	44.6	62.0	36	49.0	23.9	48.6	20.7
1889	39	12	42	14	54	28	62	37	66	41	76	48	84	56	85	57	73.0	44	62	38	43	21	54	28
1890	43	13	47	18	53	24	60	35	68	42	80	50	86	58	82	53	75.0	45	64	35	55	26	54	22
1891	43	12	49	17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1892	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	54.9	26.2	36.6	14.5
1893	47.5	22.3	40.1	17.7	49.9	23	55	30.4	64.4	38.8	79.3	48.9	81.6	55.3	75.5	52.7	73.9	46	62.7	34.0	49.3	22.6	45.9	22.6
1894	41.8	14.4	35.7	10	49.6	24.9	52.7	32.0	68.1	43.2	75	49	78.4	55.2	78.1	52.4	72	44	65	33	56.3	27.0	41.9	17.9
1895	39.4	16.1	36.7	12.4	46.9	22	60.3	32.6	64.0	40.2	71.6	46.9	74.9	51.9	77.8	53.1	77.4	47.1	60.4	33.6	47.6	22.6	40.5	16.5
1896	48.2	21.8	45.1	20.8	45.7	23	61.6	34.4	69.6	42.7	79.5	49.3	81.0	55.7	80.0	54.1	69.4	45.9	59.9	35.0	46.8	21.2	50.4	23.2
1897	37.7	13.2	39.8	17.9	45.7	23.6	55.9	32.4	67.8	43.7	76.1	48	80.5	52.2	77.8	53.1	75.4	49.5	61.2	35.8	53.2	27.2	40.3	15.1
1898	39.1	13.5	47.6	22	46.0	21.4	59.0	34.2	60.9	40.1	74.5	49.7	79	55.3	81.8	54.1	73.4	44.0	58.5	31.7	47.1	21.4	38.1	12.0
1899	38.9	14.3	29.2	4	47.0	20.4	62.8	33.0	69.5	39.3	77.8	48.7	79.2	53.8	82.5	55.2	78.3	47.5	62.4	36.1	54.8	29.5	41.6	18.7
1900	46.7	19.7	43.8	14.7	54.3	26.7	51.5	30.5	67.1	43.9	79.6	51.2	81.9	51.8	83.3	51.8	72.8	46.0	66.5	38.0	55.2	26.1	46.7	19.6
1901	41.6	18.4	40	14.0	49.1	23.5	55.4	31.6	64.7	43.0	79.6	48.8	85.8	55.9	80.2	54.9	73.7	43.8	65.8	36.1	57.2	27.7	45.7	18.6
1902	40.8	14.4	.....	21.3	47	22.6	60.1	33.0	69.8	44.2	79.8	49.6	80.2	51.5	81.9	54.0	73.6	41.2	63.4	37.0	51.5	24.5	46.7	18.6
1903	45.0	19.9	31.3	9.8	49.5	23.9	58.4	32.7	65.6	38.7	68.7	47.0	83.2	54.0	81.9	49.6	73.4	42.8	66.2	35.5	55.2	25.7	48.4	19.5

MAXIMUM DAILY RANGE OF TEMPERATURE

FOR THE MONTHS—WITH DATE.

YEAR.	JAN. Range.	JAN. Date.	FEB. Range.	FEB. Date.	MARCH. Range.	MARCH. Date.	APRIL. Range.	APRIL. Date.	MAY. Range.	MAY. Date.	JUNE. Range.	JUNE. Date.	JULY. Range	JULY. Date.	AUGUST. Range.	AUGUST. Date.	SEPT. Range.	SEPT. Date.	OCT. Range.	OCT. Date.	NOV. Range.	NOV. Date.	DEC. Range.	DEC. Date.
1883	....	....	....	....	....	....	....	....	....	....	....	....	41	1	37	23	37	30	35	2	40	27	36	4
1884	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1885	....	....	....	....	....	....	43	9	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1886	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1887	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1888	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1889	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1890	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	55	9
1891	57	13	....	....	48	16	52	29	36	7	....	....	....	....	46	25	....	....	....	....	....	....		
1892	....	....					....	....	....	....							....	....	....	....	47	14	48	22
1893	42	8	42	2	47	6	40	23	42	23	45	7	35	17	33	13	38	11	40	15	40	12	39	13
1894	43	29	45	24	46	29	42	14	37	10	39	28	33	23	38	28	....	....	....	....	47	24	39	4
1895	45	4	52	16	37	11	46	2	41	8	44	5	36	18	40	25	41	23	38	12	47	26	43	27
1896	43	4	41	9	39	20	44	2	40	26	40	12	37	1	42	12	41	15	34	31	48	22	37	1
1897	39	8	42	27	33	10	35	17	37	17	41	19	42	13	36	25	34	2	38	11	40	19	42	4
1898	40	1	40	5	47	24	44	2	38	22	38	28	36	26	36	4	41	25	45	6	41	6	46	4
1899	48	29	47	12	44	6	45	9	41	18	39	11	36	5	38	21	42	29	41	20	36	14	46	15
1900	48	29	53	18	41	8	33	1	35	10	36	27	43	12	40	15	37	30	37	26	46	21	43	29
1901	45	3	41	16	53	6	38	2	32	8	42	25	35	7	36	1	55	21	44	16	43	12	46	17
1902	40	6,13	42	20	41	18	39	30	38	7	37	24	40	15	40	10	48	4	39	7	45	17	53	8
1903	39	30	37	16	37	11	38	27	40	1	41	29	35	15	40	3	47	10	42	18	43	9	40	11

TOTAL MONTHLY WIND MOVEMENT.

	Jan.	Feb.	March.	April	May	June	July	August	Sep.	Oct.	Nov.	Dec.
Year.	Miles	Miles	Miles	Miles	Miles	Miles	Miles	Miles	Miles	Miles	Miles	Miles
1893	3,472	3,332	9,393	9,359	8,679	7,060	....	....	....	6,813	8,026	6,846
1894	8,351	6,370	9,063	8,755	7,876	7,417	5,782	5,218	....	....	....	....
1895	7,812	....	....	....	7,998	....	....	....	....	....	....	5,425
1896	6,293	7,540	7,967	9,796	8,682	6,124	5,466	5,208	5,472	5,829	5,797	5,538
1897	5,686	....	....	7,701	6,079	6,918	5,389	4,844	4,954	7,270	5,735	6,336
1898	5,167	5,802	7,429	6,901	6,594	5,701	5,451	5,416	6,153	6,689	7,083	6,503
1899	6,769	5,740	7,290	7,928	8,132	5,752	5,557	6,063	5,652	6,404	6,306	6,633
1900	5,215	7,242	6,074	6,509	5,990	....	....	....	....	....	....	....
1901	4,781	3,381	6,472	3,800	5,800	5,795	....	1,630	4,346	4,559	....	6,882
1902	4,905	5,981	7,845	6,733	6,080	6,415	5,512	....	6,091	5,772	5,141	7,215
1903	6,741	5,041	5,275	6,858	7,920	....	....	....	....	6,192	3,482	5,746

MAXIMUM WIND VELOCITY,—MILES PER HOUR,

FOR THE MONTHS—WITH DATES.

YEAR.	JAN.		FEB.		MARCH.		APRIL.		MAY.		JUNE.		JULY.		AUGUST.		SEPT.		OCT.		NOV.		DEC.	
	Velocity.	Date.	Velocity.	Date.	Velocity.	Date.	Velocity.	Date.	Velocity.	Date.	Velocity.	Date.	Velocity.	Date.	Velocity.	Date.	Velocity.	Date.	Velocity.	Date.	Velocity.	Date.	Velocity.	Date.
1893	58	31	54	8	57	31	58	6	55	19	60	26	39	12	38	8	46	30	55	23	65	21	52	2
1894	73	22	64	20	66	10	52	30	48	15	49	4	40	29	35	8	.....	.....	.....	.....	.....	.....	.....	.....
1895	.....	.....	.....	.....	.....	.....	.....	.....	52	28	.....	.....	.....	.....	.....	.....	.....	.....	36	27	40	22	72	30
1896	54	19	44	27	55	26	53	10	48	30	38	24	40	23	36	22	40	24	40	29	40	.....	50	5
1897	36	17	31	13	62	31	45	7	34	22	40	18,22	54	3	48	1	30	25	45	26	44	8	72	7
1898	60	29	53	4	65	14	43	3,4	32	13	40	22	40	7	35	15	35	16	47	1	48	20,21	50	2
1899	50	23	44	21	56	14	45	17,19	45	21	45	20	32	6,7	40	15	45	13	40	2	52	30	48	16,31
1900	64	29	52	2	64	6	60	2	43	23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1901	.....	.....	.....	.....	55	4	34	3	48	22	48	5	48	8	40	11	.....	.....	45	12	40	.....	64	.....
1902	44	25	60	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1903	64	6	32	.....	43	17	64	1	64	22	.....	.....	.....	.....	.....	.....	.....	.....	36	6	50	10	40	21

PREVAILING MONTHLY WIND DIRECTION.

Year	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
	Direction	Direction	Direction	Direction	Direction	Direction	Direction	Direction	Direction	Direction	Direction	Direction
1893	N.	N.	N.	N.	N.	N.	N.	N.	N.	N.	N.	N.
1894	N.	N.	N.	N.	N.	N.	N.	N.	N.	N.	N.	N.
1895	S. E.	N. W.	N.	N.	N.	S. E.	S. E.	N. W.	S. E.	S. E.	N. W.	N. W.
1896	N.	N.	N.	S.	S. E.	S. E.	S. E.	S. E.	N.	N.	N.	N.
1897	N.	N.	S. E.	N.	N.	N.	N.	N.	S. E.	S. E.	N.	N.
1898	N.	N.	S. E.	S. E.	S. E.	N.	N.	S. E.	S. E.	N.	N.	N.
1899	N.	N.	N.	S. E.	S. E.	S. E.	S. E.	S. E.	S. E.	N.	N.	N.
1900	N.	N.	S. E.	N.	S. E.	N.	S.	S. E.	S. E.	S. E.	N.	N. W.
1901	N. W.	S. E.	N.	N. E.	S. E.	S. E.	S.	N.	S. E.	V.	V.	N. W.
1902	....	N. W.	N.	V.	S. E.	S. E.	V.	S. E.	S. E.	S.	S.	N.
1903	N.	N.	S. E.	N.	N.	N.	S.	S.	S. E.	N.	N.	N.

MEAN MONTHLY RELATIVE HUMIDITY.

	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
Year	Rel. Hum.	Rel. Hum.	Rel. Hum.	Rel. Hum.	Rel. Hum.	Rel. Hum.	Rel. Hum.	Rel. Hum.	Rel. Hum.	Rel. Hum.	Rel. Hum.	Rel. Hum.
1877	...	...		...	...	...	...	...	...	...	...	52
1878	53	...	...	37	49	56	54	53	45	35	52	62
1879	...	67	...	...	...	...	...	...	...	...	...	...
1880	32	...	...	...	...	...	...	...	...	...	...	...
1881	...	...	...	...	...	...	...	...	...	...	...	...
1882	...	...	...	...	...	...	...	...	...	...	...	...
1883	...	...	54	55	48	...	...	...	...	...	...	...
1884	...	...	...	...	...	...	...	...	...	...	...	...
1885	...	...	...	...	...	...	...	...	...	...	...	...
1886	...	...	...	57	34	...	50	61	48	47	...	61
1887	...	60	42	52	51	...	60	60	58	59	50	60
1888	55	59	54	45	55	39	50	53	54	56	67	57
1889	...	61	57	50	55	...	53	55	51	62	67	66
1890	62	58	55	59	59	43	49	57	45	42	48	...
1891	...	...	...	...	...	...	...	...	...	...	...	...
1892	...	...	...	...	...	...	...	...	...	...	...	...
1893	44	53	47	43	49	41	50	61	41	49	47	47
1894	45	55	45	41	47	46	54	58	46	49	43	38
1895	54	60	52	53	49	65	60	59	46	55	54	65
1896	50	56	68	46	42	45	53	53	65	64	54	44
1897	61	67	53	53	58	49	43	57	49	47	53	61
1898	60	52	57	61	70	...	54	45	40	45	49	57
1899	54	67	54	37	33	41	56	40	38	44	47	55
1900	55	56	46	70	50	...	...	...	...	...	...	...
1901	...	...	...	...	...	...	...	...	...	...	...	...
1902	...	...	...	62	...	...	...	...	...	...	...	...
1903	...	68	...	...	...	...	...	...	...	...	...	...

TOTAL MONTHLY PRECIPITATION.

Year.	Jan. Precip.	Feb. Precip.	March. Precip.	April. Precip.	May. Precip.	June. Precip.	July. Precip.	August. Precip.	Sept. Precip.	Oct. Precip.	Nov. Precip.	Dec. Precip.
1872	.09	.24	1.10	2.05	3.24	2.35	4.71	3.75	.50	.04	.26	.23
1873	.03	.05	.19	.96	1.76	2.65	4.53	3.28	1.70	.65	.00	.15
1874	.06	.54	.50	3.55	5.90	.20	.81	.91	3.37	.19	.35	.15
1875	.24	.56	1.12	.30	1.03	1.82	6.07	2.39	2.23	.13	1.19	.29
1876	.12	.19	.63	.52	3.83	1.89	1.36	....	....	....	....	....
1877	....	....	....	....	....	....	....	....	....	....	.22	.18
1878	.02	.02	1.80	.20	1.69	3.78	2.80	1.66	1.12	.45	1.10	1.66
1879	.38	.09	.73	1.43	2.23	.42	....	....	....	....	....	....
1880	.22	.24	.59	....	....	....	5.27	....	....	....	....	....
1881	....	....	....	....	....	....	....	....	....	....	....	....
1882	....	....	....	....	....	....	....	....	....	....	....	....
1883	.35	0	.17	.86	1.51	....	....	.97	1.78	....	.00	....
1884	....	....	....	....	....	....	....	....	....	....	....	....
1885	....	....	.12	1.33	1.84	....	....	....	....	....	T	....
1886	.60	.25	.39	4.82	.12	3.06	2.91	1.39	.33	.28	.19	.15
1887	.06	.22	.19	1.54	2.24	1.88	4.75	1.42	.80	.35	.40	.08
1888	.10	.45	.28	1.51	2.42	.01	1.91	1.18	.13	.84	.22	.07
1889	.16	.60	.12	1.17	2.34	1.77	2.88	1.49	.86	2.08	.16	.14
1890	.41	.13	.39	3.90	1.43	.44	1.64	4.99	.17	.40	.28	....
1891	....	....	....	....	....	....	....	....	....	....	....	....
1892	.30	.11	1.32	.38	2.01	1.62	2.96	.68	.08	1.54	....	....
1893	.01	.08	.03	.54	1.34	.40	2.51	3.06	.21	.24	.14	.03
1894	.03	.65	.36	.25	7.34	3.95	2.95	1.38	.87	.15	.22	.42
1895	.10	.71	.40	.60	2.70	4.56	3.79	1.89	.15	1.66	.32	.18
1896	.13	.13	2.21	.72	.81	1.37	3.10	2.43	2.58	.36	.03	.07
1897	.10	1.02	.48	.54	1.27	.80	3.34	2.55	.74	.54	.19	.06
1898	.18	.21	.28	1.54	3.32	3.61	2.98	.56	.27	.24	.18	.43
1899	.23	.15	.92	.02	.67	1.73	2.57	.79	.08	1.09	.01	.55
1900	.05	.11	.17	6.78	2.03	1.03	1.20	.74	.61	.53	.31	.08
1901	.06	.16	1.29	2.64	3.49	2.39	1.92	2.24	2.20	.49	.01	.18
1902	.14	.25	.77	.82	5.23	1.56	1.66	2.69	1.60	.51	.02	.22
1903	.11	.70	.37	.93	.62	5.10	.43	2.57	....	.34	.25	.05

MAXIMUM DAILY PRECIPITATION.

FOR THE MONTHS—WITH DATE.

YEAR.	JAN.		FEB.		MARCH.		APRIL.		MAY.		JUNE.		JULY.		AUGUST.		SEPT.		OCT.		NOV.		DEC.	
	Precip.	Date.	Precip.	Date.	Precip.	Date.	Precip.	Date.	Precip.	Date.	Precip.	Date.	Precip.	Date.	Precip.	Date.	Precip.	Date.	Precip.	Date.	Precip.	Date.	Precip.	Date.
1887	....	....	....	....	....	....	....	....	....	....	....	....	.23	....	1.44	....	0.30	....	.19	....	0.36	....	.02	....
1888	.05	....	.25	....	.11	....	1.37	....	1.20	....	.01	....	.72	....	.48	....	.08	....	.76	....	.11	....	.04	....
1889	.12	....	.42	....	.06	....	.41	....	1.09	....	.56	....	1.26	....	.47	....	.78	....	.90	....	.08	....	.14	....
1890	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1891	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1892	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1893	....	....	.02	....	.02	7	.33	13	.80	6	.17	4	....	....	....	....	....	....	.14	1	.08	26	.03	5
1894	.02	11	.48	21	.16	25	.10	30	1.34	23	.86	6	.68	4	.31	14	....	....	....	....	.22	17	.19	25
1895	.06	20	.13	10	.14	5	.39	21	1.53	30	1.12	10	1.17	11	.63	28	.14	1	1.25	4	.18	24	.09	14
1896	.12	29	.13	3	1.32	1	.21	12	.31	31	.47	19	1.42	16	.94	21	.90	3	.13	22	.01	....	.06	31
1897	.06	1	.71	10	.26	30	.12	29	.37	30	.24	11	1.71	19	1.17	4	.35	16	.23	8	.07	4	.03	2
1898	.13	21	.21	18	.21	29	1.05	11	.85	3	1.10	7	.70	13	.35	23	.24	10	.12	19	.11	27	.32	8
1899	.09	30	.06	2	.37	26	.01	30	.66	6	.81	9	1.03	13	.24	6	.04	16	.43	25	.01	23	.51	.13
1900	.04	28	.04	15	.12	14	1.64	5	1.53	20	.41	10	.70	24	.40	5	.21	3	.35	15	.24	27	.08	30
1901	.06	30	.10	22	.62	29	1.30	11	1.13	31	1.71	15	1.03	15	.52	30	1.42	1	.38	6	.01	18	.07	12
1902	.04	17	.13	18	.30	28	.39	14	1.42	27	1.10	28	.71	17	.94	5	1.30	21	.25	11	.02	15	.20	13
1903	.05	11	.16	12	.30	7	.32	20	.46	.26	1.27	7	.15	17,19	1.10	7	.50	29	.25	14	.25	16	.03	23

NUMBER OF DAYS CLEAR, PARTLY CLOUDY, AND CLOUDY.

Year.	Jan. Clear.	Jan. Partly Cloudy.	Jan. Cloudy.	Feb. Clear.	Feb. Partly Cloudy.	Feb. Cloudy.	March. Clear.	March. Partly Cloudy.	March. Cloudy.	April. Clear.	April. Partly Cloudy.	April. Cloudy.	May. Clear.	May. Partly Cloudy.	May. Cloudy.	June. Clear.	June. Partly Cloudy.	June. Cloudy.
1872	25	4	2	25	3	1	16	12	3	22	6	2	14	13	4	19	6	5
1873	20	11	0	18	10	0	22	8	1	14	10	6	14	11	6	16	12	2
1874	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1875	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1876	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1877	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1878	16	10	5	4	20	4	6	12	13	12	15	3	9	11	11	2	18	10
1879	22	7	2	12	11	5	14	13	4	11	11	5	14	12	5	16	12	2
1880	9	19	3	13	15	1	13	15	3	...	...	...	...	...	...	...	...	...
1881	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1882	26	3	2	...	...	...	23	6	2	13	11	6	...	...	...	...	...	...
1883	16	10	5	17	11	0	11	17	3	4	21	5	6	17	8	...	...	...
1884	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1885	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1886	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1887	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1888	17	13	1	11	13	5	14	13	4	9	16	5	2	23	6	16	14	0
1889	17	8	6	11	11	6	9	13	9	11	10	9	7	16	8	15	10	5
1890	17	10	4	16	10	2	13	13	5	10	13	7	10	16	5	16	12	2
1891	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1892	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1893	19	10	2	8	11	9	11	13	7	12	10	8	11	10	10	14	13	3
1894	15	15	1	9	13	6	8	16	7	14	10	6	8	13	10	13	12	5
1895	10	11	10	16	2	10	19	7	5	16	9	5	11	5	15	13	3	13
1896	10	12	9	16	6	7	6	8	17	15	11	4	11	11	9	9	10	11
1897	22	7	2	12	9	7	16	8	7	9	13	8	10	11	10	10	10	10
1898	20	5	6	14	7	7	14	6	11	8	9	13	5	7	19	9	11	10
1899	18	10	3	13	10	5	13	9	9	22	6	2	26	5	0	21	8	1
1900	19	9	3	16	11	1	8	16	7	5	12	13	9	14	8	4	20	6
1901	16	12	3	12	12	4	9	15	7	11	9	10	5	15	11	14	13	3
1902	19	10	2	6	19	3	9	16	6	12	13	5	9	13	9	10	12	8
1903	14	15	2	11	9	8	12	14	5	14	7	9	15	12	4	5	11	14

Year.	July. Clear.	July. Partly Cloudy.	July. Cloudy.	August. Clear.	August. Partly Cloudy.	August. Cloudy.	Sept. Clear.	Sept. Partly Cloudy.	Sept. Cloudy.	Oct. Clear.	Oct. Partly Cloudy.	Oct. Cloudy.	Nov. Clear.	Nov. Partly Cloudy.	Nov. Cloudy.	Dec. Clear.	Dec. Partly Cloudy.	Dec. Cloudy.
1872	18	10	3	18	9	4	25	4	1	25	6	0	21	7	2	17	8	6
1873	15	16	0	18	12	1	22	6	2	21	6	1	24	5	1	16	14	1
1874	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1875	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1876	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1877	...	...	...	...	...	...	...	...	...	...	...	...	22	7	1	22	7	2
1878	10	16	5	5	17	9	11	13	3	23	5	3	13	9	8	14	8	9
1879	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1880	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1881	...	...	...	...	...	...	...	...	...	...	...	...	17	9	1	...	...	...
1882	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1883	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1884	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1885	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1886	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1887	6	21	4	11	14	6	14	12	4	4	12	5	15	11	4	15	13	3
1888	14	16	1	10	16	5	19	11	0	12	14	5	18	8	4	21	8	2
1889	19	12	0	13	17	1	17	11	2	18	6	7	15	10	5	19	11	1
1890	3	26	2	10	15	6	10	16	4	20	4	7	23	5	2	...	...	...
1891	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1892	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1893	9	14	8	7	17	7	21	7	2	19	11	1	19	6	5	16	9	6
1894	8	18	5	11	16	4	20	7	3	...	...	...	17	8	5	15	8	8
1895	10	11	10	10	13	8	20	10	0	21	6	4	16	11	3	16	8	7
1896	9	14	8	9	14	8	10	8	12	14	6	11	16	12	2	20	6	5
1897	16	8	7	18	9	4	14	8	8	18	6	7	21	5	4	21	3	7
1898	14	15	11	21	8	2	24	4	2	23	4	4	22	7	1	19	9	3
1899	11	11	6	18	10	3	19	6	5	16	8	7	18	9	3	17	10	4
1900	5	7	19	4	19	8	14	11	5	20	8	3	16	12	2	20	9	2
1901	16	14	1	7	21	3	14	13	3	20	7	4	20	8	2	16	10	5
1902	15	11	5	10	17	4	23	4	3	18	9	4	14	14	2	17	11	3
1903	12	17	2	11	18	2	17	11	2	24	4	3	24	4	2	24	7	0

THE EVOLUTION OF THE SNOW-CRYSTAL.
(Second Paper.)

John C. Shedd.

In the Meteorological summary for 1904 (Vol. XI, No. 41) the following conclusions were arrived at with respect to the character of snow-crystals:

1. Storms generally begin with granular snow in the form of pellets.

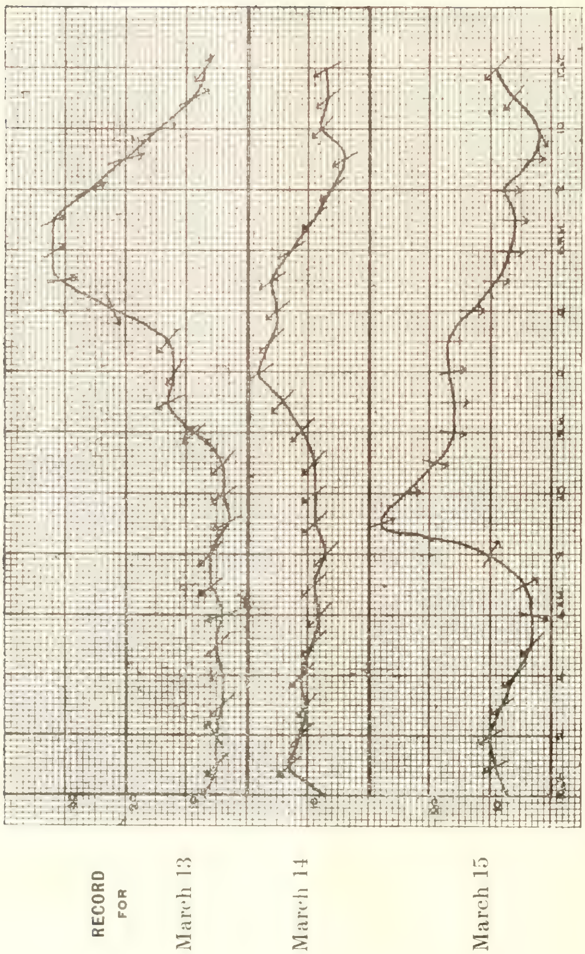
2. As the storm progresses granular snow with crystalline centers make their appearance, followed by the open ("fern stellar") type.

3. The more solid forms next appear and become more numerous, while the open type of crystal generally stops.

4. In the case of light snow, the crystals from high clouds are preponderantly of the solid nucleus type, while those from low lying clouds are generally of the open structure type.

The general correctness of these conclusions seem to be borne out by the observations of the present season. On one occasion in particular the opportunity was afforded for checking on the 4th point above noted. The present paper has to do with these observations.

The week ending March 17, 1906, was one somewhat characteristic of this time of the year in which the A. M. hours are apt to be cloudy while the P. M. hours are generally clear. In the present instance the days Tuesday, Wednesday and Thursday (March 13, 14, 15) are under discussion. The meteorological record for these days is given in the following curves, showing wind direction and velocity, barometric pressure and temperature.



CURVE I.—Wind Velocity and Direction.

Note.—The ordinates show *miles per hour* for the hours given on the base line.

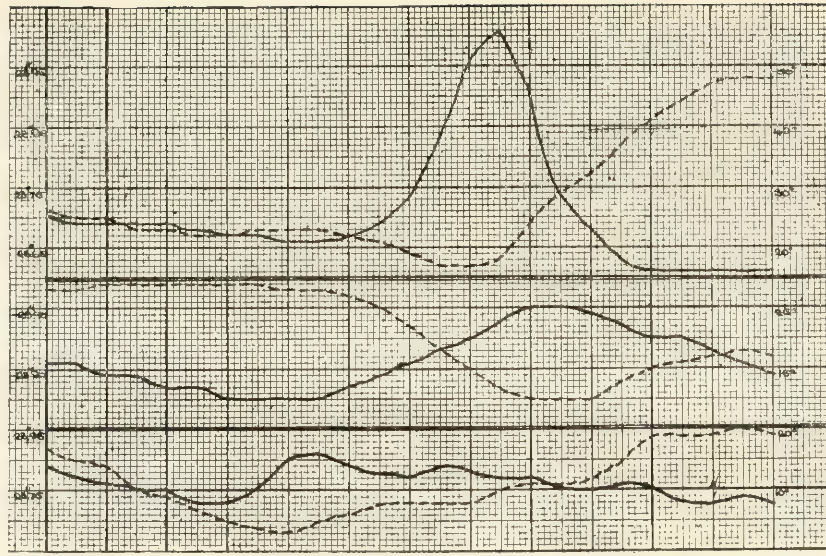
The arrows show the direction of the wind, *e.g.* a N. wind is shown by a downward pointing arrow.

RECORD FOR

March 13

March 14

March 15



Curve II.—The hours are on base line as in Curve I.

Temperature: shown by *full* line, the temperature scale being on the right.
Barometric Pressure: shown by *broken* line, the pressure scale being on the left.

A study of the original record sheets leads to the following summary of the weather conditions prevailing on these days.

TEMPERATURE.

Tuesday—A. M., 21° to 28° with min. at 8 o'clock P. M., max. 56° at 3 o'clock and falling to 16° at midnight.

Wednesday—A. M. the temperature continues to fall, reaching 10° at 8 A. M., and is then followed by the daily rise, reaching 25° at 4 P. M. The general temperature is much lower than on Tuesday.

Thursday—At midnight the temperature is 14° and it continues to fall until 8° is reached at 5 o'clock A. M. The max. is 16° at 9 A. M. At 6 P. M. it is 10° and at midnight 8°. The general temperature is decidedly lower than on either of the previous days.

WIND DIRECTION.

Tuesday—From midnight until 3 P. M. the wind was from the S.E. From 3 P. M. until 11 P. M. it was from the N. and N.W.

Wednesday—At midnight the wind shifted back to the S.E. and remained from this direction throughout the 24 hours.

Thursday—Continued from the S.E. until 5 A. M. Between 5 and 6 the direction shifts to the N.W. and N. and so remains until 9 P. M. At this hour it returned to the S.E. and so remained until 6 A. M. of the next day.

WIND VELOCITY.

Curve No. I shows the miles of wind recorded during each hour of the three days. The arrows indicate the mean direction of the wind for the hour.

Precipitation.

On Tuesday the snowfall was too light to leave a record, but gave admirable opportunity for crystal study. On Wednesday the snow began falling during the night and ended at 12:30 P. M. The snow was for the most part in flurries and was at no time heavy. The measured precipitation was 0.11 inch. On Thursday the snow began at 9:45 A. M. and continued for the rest of the day. The measured amount was 0.80 inch. (Measured after melting.)

Clouds.

Tuesday, A. M.	Cloudy,	P. M.	Clear.
Wednesday, A. M.	Cloudy,	P. M.	Clear.
Thursday, A. M.	Cloudy,	P. M.	Clear.

Barometer.

The noticeable feature about the barometer curves is the fact that the pressure was below normal throughout the three days. (The normal pressure is very approximately 24 inches.)

Lake Moraine Station.

A sub-station of the Bureau is located at Lake Moraine, 9.3 miles west of the city, and on the S.E. slopes of Pike's Peak. Its elevation is 10,247 feet above sea level or 4,250 feet above the city. The station is in a wide depression of the mountains, with the Peak rising 3,900 feet above it on the N.W. To the south rises Bald Mountain, 12,347 feet, while on the east is Cameron's Cone, 10,685 feet high. Between these peaks are gaps of elevation of about 10,000 feet.

There is telephonic communication with the city and on the days in question inquiry was made as to the weather conditions. On Tuesday and Wednesday it was reported "clear" throughout the whole time, while on Thursday snow began flying at 6 A. M. The following is the meteorological record for these days, as printed each day in the *Evening Telegraph*.

	MARCH 13	MARCH 14	MARCH 15
Max. Temp...	11 A. M...36°	12 M......40°	11 A. M...19°
Min. Temp...	3 A. M...22°	12 Mid'nt. 4°	6 A. M...15°
Mean Temp............	24 .5	..........22°	....
Max. Bar.....	9 A. M...20.25	12 Mid'nt.20.20	7 P. M...20.15
Min. Bar.....	3 A. M...20.15	11 P. M...20.15	11 A. M...20.10
Snow Fall in Inches....	0.0	.... 0.0	.... 3.0

A study of the daily weather maps issued by the Denver office of the U. S. Weather Service gives the following as the general weather conditions existing over Colorado for these three days.

A low area over the Arizona plateau persisted throughout the whole period, sending an offshoot to the S.E., but not quitting its position, while an anticyclone in the upper Mississippi valley opposed it. The interaction between the two resulted in changeable local conditions.

TOPOGRAPHY OF COLORADO SPRINGS.

Colorado Springs is at an elevation of 6,000 feet above sea level. Six miles to the west and running N. to S. the range rises to a height of 11,000 feet, while the gaps between peaks are some 10,000 feet high. To the E. and S. lie the plains, falling to lower levels.

From the foregoing it would seem to be established: I. That during the A. M. of the 13th and during all of the 14th there was an air current up from the low lands in the S.E., bringing with it a moderate amount of moisture. This supply of moisture, partially condensed by the dynamic cooling due to expansion, formed a thin cloud layer whose upper side did not extend above the ten or eleven-thousand-foot level (as witnessed by the clear sky at Lake Moraine). The snow crystals received on these days were therefore from low-lying clouds and (since the wind was very light) could have been in the air but for a short time.

II. It also seems evident that between five and six o'clock on the 15th a counter current from the north set in, attaining by ten o'clock a surface velocity of 28 miles. At Lake Moraine snow began falling at 6 A. M., while in the city it began to fall at about 9:45 A. M. Upon the weather clearing it was also seen that there had been somewhat of a fall of snow on the summit of the Peak. The clouds must therefore have stood above the summit of the Peak to a considerable height. Since the fall of snow on the Peak was heavy enough to evidence itself from the city the cloud layer must have had considerable thickness. Assuming this thickness to have been not less than 6,000 feet, it is seen that on this date the clouds stood above the city to a height of not less than 14,000 feet. Further by reason of the higher wind velocity the snow may on this account have been kept suspended in the air somewhat longer.

The contrast of conditions prevailing on the 13-14 with those of the 15th is striking and the contrast between the character of the snow-crystals no less so. On the first two days all of the crystals seen were of the large branching open "fern-stellar" type. This type is illustrated by Figs. 1, 2 and 3 (frontispiece). There were none of the solid tabular or of the compound crystals. (Fig. 8, frontispiece Colorado College Studies No. 41.)

On the other hand on the 15th all of the crystals seen were found to be of the small solid tabular type. There were no compound crystals. Figs 4, 5 and 6 illustrate this type, both as to general character and also relative size as compared with Figs. 1, 2 and 3. From these observations the conclusion previously reached is confirmed, viz., that crystals from low-lying clouds are of the open "fern-stellar" type, while crystals from high-lying clouds are of the solid tabular type. This conclusion is confirmatory of the hypothesis indicating an evolution of the crystal from the former to the latter type. This hypothesis is here repeated as given in a previous paper.

I. The primitive crystal is, for the tabular form, the "fern-stellar" type, i. e., open in structure and with many branches. (Fig. 8, C. C. Studies, No. 41.) For the columnal form it is the hollow column.

II. The solid tabular, solid columnar or granular forms are the final forms of crystal to which all others tend. The doublet is a combination of the first two.

III. There is a process of transformation from the primitive to the final forms, the process being subject to many varying conditions which generally leave their impress upon the crystal.

IV. There are two general processes: First, a process of accretion in which new material is added to the crystal; second, a process of transformation in which the losses and gains result in a change in form, but not necessarily in amount of material.

In the present case the crystals of the 13th and 14th would seem to be primitive crystals but slightly modified. Those of the 15th coming from greater heights and kept longer in the air are examples of the modified crystal.

Colorado Springs affords admirable opportunities for snow-crystal study and it is to be hoped that at some not distant date the station on the summit of the Peak may be re-established by the U. S. Government, under conditions favorable for research. Such a station 8,000 feet above the city would be of great help in the present problem.

It is a pleasure to acknowledge the co-operation of Dr. F. H. Loud in the preparation of this paper, more especially in the interpretation of the weather maps.

PHYSICAL LABORATORY,
COLORADO COLLEGE, May 20, 1906.

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F. H. LOUD, Director

Notes on the Computation of Logarithms

F. H. Loud

COLORADO SPRINGS, COLORADO

JANUARY, 1907

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(*Continued on inside of back cover.*)

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NOTES ON THE COMPUTATION OF LOGARITHMS

By F. H. Loud

The three hundredth anniversary is approaching of one of the most important of labor-saving devices in the history of civilization,—the discovery of logarithms. The first publication in which it was announced by Napier, "*Mirifici logarithmorum canonis descriptio*," dates from 1614. The tables of Briggs and Vlacq, presenting the new instrument of computation in the form in which it has ever since been indispensable, were issued from 1624 to 1628. It would be fitting if in 1914, a volume should appear,—perhaps in Edinburgh,—embodying all the most efficient computative devices with which the idea of Napier has been enriched by the labors of his followers, and extending the tables to a new degree of precision. Such a work might well occupy the seven years to its suggested date. The *Tables du Cadastre*, the most extensive thus far, were prepared, it is true, in two years, but they required the labor of about a hundred computers.

Wonder appears to have been the foremost sentiment excited in the inventors by their own invention,—as if it had been an inspiration. Note the first word of Napier's title, and the exclamation of Briggs:—"I never saw a book which pleased me better (than the *Descriptio*) or made me more wonder." The same sentiment is aroused in the modern reader who examines the methods by which Briggs set to work to ocmpute his tables. The patient diligence demanded by the rude processes then available,—ingenious though they were,—must excite admiring gratitude.

The *Encyclopædia Britannica*, in the articles "Logarithms" and "Tables," contains references to all those facts in the history of the subject which I have occasion to cite in the present sketch, and gives a fairly complete outline of the method of Briggs,—quite sufficient to enable the reader to imagine the toil involved in its execution. But the work of Briggs and Vlacq remains the basis of all present logarithmic tables,—later inventions have but served to show how much more easily it might have been done, could theory have sprung at once, full armed, from the brain that conceived the idea.

The method of infinite series came in with Newton,* and since then the two formulae

$$\log (1+x) = M \left\{ x-\tfrac{1}{2}x^2 + \tfrac{1}{3}x^3 - \tfrac{1}{4}x^4 + \text{etc.} \right\}$$
$$\log \tfrac{1+x}{1-x} = 2M \left\{ x+\tfrac{1}{3}x^3 + \tfrac{1}{5}x^5 + \text{etc.} \right\}$$

—the latter a mere modification of the former—have been the basis of logarithmic computation.

The present article deals with some very convergent forms into which the second of these series might be thrown, were it desirable to extend by its means the existing tables. The computations embodied in it lead of course to no new results, as (for instance) the logarithms of primes up to 109, to 102 places, have been published in the "Astronomical Tables" of Parkhurst, New York, 1871. But a search for improved methods of treatment has perhaps some interest, even if not carried so far as preceding computations have gone.

The first step in an entirely independent handling of

*The logarithmic series is attributed to Mercator, whose *Logarithmotechnica* was published in London in 1668, the year before Newton was appointed professor of mathematics at Cambridge. See Cajori's *History of Mathematics*, p. 197.

the problem—such, for instance, as might be undertaken by an astronomer who should succeed in voyaging, without his books, to the planet Mars, and should desire to introduce Napier's invention to the enlightened population of that planet,—would be the recomputation of the modulus. I here assume that this number would be the same as with us,—though this would not be the case unless the Martians employ the decimal system in counting. If they use a radix of 16 instead of 10, with such a notation as Mr. Farquhar of Washington proposed some twenty years or more ago, their computations,—as he conclusively proved,—must be so much easier than those in use on our planet that logarithms would be of far less relative importance. But mankind, for anatomical reasons which appealed to our primitive ancestry, has definitely adopted the radix ten, hence the only modulus with which we are concerned is the reciprocal of the natural logarithm of that number.

This modulus has been calculated with seemingly sufficient exactness by Professor J. C. Adams, the theoretical discoverer of the planet Neptune. That discovery was the exploit of his young manhood, while in his later years he found a pastime in numerical work, such as the computation of the numbers of Bernouilli. In 1878 he contributed to the Proceedings of the Royal Society an essay containing a determination of the value of M which is quoted in the authority already cited:

$$M = 0.\ 43429\ 44819\ 03251\ 82765\ 11289$$
$$18916\ 60508\ 22943\ 97005\ 80366$$

and so forth, to 282 places of decimals. The outline of his process is given, whence it appears that he found the natural logarithms of $\frac{10}{9}$, $\frac{25}{24}$, $\frac{81}{80}$, $\frac{50}{49}$ and $\frac{126}{125}$. If these logarithms be designated by the letters a, b, c, d, e, the natural logarithm of ten is

$$\log_e 10 = 23a - 6b + 10c, \text{ for } 10 = \frac{2^{23}.5^{23}}{3^{46}} \cdot \frac{2^{18}.3^{6}}{5^{12}} \cdot \frac{3^{40}}{2^{40}.5^{10}}$$

The use of d and e was confined to verification, the whole computation being checked by means of the identity,

$$a - 2b + c = d + 2e.$$

The form of his fundamental equations, $a = -\log(1-\frac{1}{10})$, $b = -\log(1-\frac{4}{100})$, $c = \log(1+\frac{1}{80})$, $d = -\log(1-\frac{2}{100})$, $e = \log(1+\frac{8}{1000})$, suggests that he probably employed the first of the two forms of the general series quoted above.

It would appear that Professor Adams, in the indulgence of his appetite for figuring, not only carried his computation to a few more decimal places than are absolutely demanded for practical uses, but in other respects disregarded parsimony of effort. He employed the logarithmic series, (if the foregoing conjecture is correct) in the less convergent of its two forms; he also found the natural logarithms, not only of 2 and 5, the factors of 10, but of 3 and 7, which are quite irrelevant to the determination of the modulus, whatever other use he may have had for them.

The two following series:

$$a = \log_e 8 = 3\log_e \frac{1+\frac{1}{3}}{1-\frac{1}{3}} = 2\left\{1 + \frac{1}{3}\cdot\frac{1}{9} + \frac{1}{5}\cdot\frac{1}{9^2} + \frac{1}{7}\cdot\frac{1}{9^3} + \text{etc.}\right\}$$

$$b = \log_e \tfrac{5}{4} = \log_e \frac{9+1}{9-1} = 2\left\{\frac{1}{9} + \frac{1}{3}\cdot\frac{1}{9^3} + \frac{1}{5}\cdot\frac{1}{9^5} + \text{etc.}\right\}$$

yield directly $\log_e 10 = a + b$, and may be checked by one other

$$c = \log_e \tfrac{128}{125} = \log_e \frac{1+\frac{3}{253}}{1-\frac{3}{253}} = \tfrac{6}{253}\left[1 + \frac{1}{3}\cdot\frac{9}{64009} + \frac{1}{5}\cdot\frac{9^2}{64009^2} + \text{etc.}\right]$$

since $\log_e 2 = \frac{1}{3}a = 3b + c$.

None of these series, to be sure, is very rapidly convergent, but the last compares not unfavorably with some of those used by Professor Adams, while the two former have the great advantage of using in the denominators the powers of the same number, 9, so that the two computations may proceed together, as follows: (Observe that the middle column is computed first.)

2. 00000 00000 00	1	2. 00000 00000 00	—	
07407 40740 74	3	22222 22222 22	1	0. 22222 22222 22
00493 82716 05	5	02469 13580 25	—	
00039 19263 18	7	00274 34842 25	3	00091 44947 42
00003 38701 76	9	00030 48315 81	—	
30791 07	11	00003 38701 76	5	67740 35
02894 89	13	37633 53	—	
00278 77	15	04181 50	7	00597 36
00027 33	17	00464 61	-	
00002 72	19	00051 62	9	00005 74
27	21	00005 74	—	
03	23	64	11	06
a=2. 07944 15416 81				b=0. 22314 35513 15

Three terms of the third series give for c the value:

c=0. 02371 65266 18.

Hence the natural logarithm of 2, =0. 69314 71805 60; of 5 = 1. 60943 79124 36; of 10 = 2. 30258 50929 96*

It should be noted that the number 9, used as a divisor in the evaluation of the first and second series, and as a multiplier in that of the third, is one with which it is especially easy to operate. In dividing by any other number, one has to employ mental subtractions, but in dividing by 9, no process but addition need be used, which is much less laborious. For instance, suppose it is required to divide by 9 the number .02469 13580 25, (as above). First, the figures of the given number are added from left to right, one at a time, the last sum, when it it is reached, being increased by the ninth part of itself. This gives the results,

2, 6, 12, 21, 22, 25, 30, 38, 38, 40, 50.

Then the last figure of the last result is set down, and the remaining figure or figures carried to the preceding, which is then treated in the same way, pro-

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* There is of course an uncertainty of two or three units in the last computed place. The correct values of the eleventh and twelfth figures of the above mantissas are as follows, (where + indicates that the thirteenth figure is 5 or more) a, 79+; b, 14; c, 17; $\log_e$ 2, 59+; $\log_e$ 5, 34; $\log_e$ 10, 94.

ducing (from right to left) the required quotient, .00274 34842 250, as in the foregoing division.

The modulus of the common system can now be obtained by the somewhat tedious process of taking the reciprocal of a + b. Then the natural logarithms of 2 and 5, found in the preceding work, are multiplied by this modulus, M, and thus their common logarithms become known. If they are computed separately, their addition affords a check on the accuracy of the work to this point. Thus

$$\begin{aligned} \log 2 &= 0.30102\ 99956\ 63+ \\ \log 5 &= 0.69897\ 00043\ 36 \\ \hline &\ 0.99999\ 99999\ 99+ \end{aligned}$$

With the determination of M, the logarithmic series becomes applicable to the calculation of common logarithms. But as the methods which are to be developed a little further on, for securing the benefit of very rapid convergence, cannot be employed with advantage until a moderate number of logarithms becomes known, it is desirable to supply these through series which commend themselves by the favorable form of the divisions. Such are the two following:

$$a = \log \tfrac{11}{9} = \log \frac{10+1}{10-1} = \frac{2M}{10}\left\{1 + \frac{1}{3 \cdot 10^2} + \frac{1}{5 \cdot 10^4} + \text{etc.}\right\}$$

$$b = \log \tfrac{101}{99} = \log \frac{100+1}{100-1} = \frac{2M}{100}\left\{1 + \frac{1}{3 \cdot 100^2} + \frac{1}{5 \cdot 100^4} + \text{etc.}\right\}$$

As before, the two computations may proceed side by side, but here it will be convenient to begin with the left-hand, instead of the middle column.

0. 86858 89638 07	1	0. 86858 89638 07	1	0. 86858 89638 07
00868 58896 38	3	00289 52965 46	100	00002 89529 65
00008 68588 96	5	00001 73717 79	100^2	00017 37
08685 89	7	01240 84	100^3	
00086 86	9	00009 65		
86	11	08		
		0. 87150 17571 89		0. 86861 79185 09
		a = 0. 08715 01757 19		b = 0. 00868 61791 85

With these is to be combined a third logarithm, that of $\frac{10000}{9999}$. In deriving this to a large number of places, it will probably be most convenient to employ the general series in its first form, writing $c = -\log(1 - \frac{1}{10000})$. This is the method heretofore mentioned as probably that of Prof. Adams, and exemplified below in computing the logarithms of 999 and 1001. But in the present illustration, carried only to twelve places, the series in its second or more convergent form reduces to a single term, viz:

$$c = \log \tfrac{10000}{9999} = \tfrac{2M}{19999} = 0.\ 00004\ 34316\ 19$$

Hence,

$$\begin{aligned}
\log 9999 &= 4 - c = & 3.\ 99995\ 65683\ 81 \\
\log 101 &= \tfrac{1}{2}(\log 9999 + b) = & 2.\ 00432\ 13737\ 83 \\
\log 99 &= \tfrac{1}{2}(\log 9999 - b) = & 1.\ 99563\ 51945\ 98 \\
\log 11 &= \tfrac{1}{2}(\log 99 + a) = & 1.\ 04139\ 26851\ 58 \\
\log 9 &= \tfrac{1}{2}(\log 99 - a) = & 0.\ 95424\ 25094\ 39 \\
\log 3 &= \tfrac{1}{2}\log 9 = & 0.\ 47712\ 12547\ 20
\end{aligned}$$

Were the logarithm of 3 the sole object of the computation, it is doubtful whether it could have been reached so easily by any other plan proceeding on an independent basis. But in the process other logarithms have been obtained, which can be used in extending the computation; for instance that of 99 can be applied to obtaining log 7 by a satisfactorily convergent series. For the square of 99 exceeds by a single unit the number 9800, whose factors, except 7, are only powers of 2 and 5.

The x of the general series must then be put equal to $\frac{1}{19601}$, viz:

$$\text{Log}\ \tfrac{9801}{9800} = \log\tfrac{19601+1}{19601-1} = 2M\left\{\tfrac{1}{19601} + \tfrac{1}{3\cdot 19601^3} + \text{etc.}\right\}$$

The square of 19601 is 3841 99201, whence the use of the latter number below.

19601	0. 86858 89638 0650		
3841 99201	00004 43135 0256	1	0. 00004 43135 0256
	00000 00000 0012	3	0004
			a=0. 00004 43135 0260

Log 9801=2 log 99	=	3. 99127 03891 96
2 + a	=	2. 00004 43135 03
log 98	=	1. 99122 60756 93
log 2	=	0. 30102 99956 64
		2 | 1. 69019 60800 29
log 7	=	0. 84509 80400 14

It is seen above that when the reciprocal of x reaches a value as high as in this case, viz., 19601, the effect of the second term of the series is not so much as half a unit in the thirteenth place of decimals.

After 2, 3, 5, 7 and 11, whose logarithms have now been completed, the next prime is 13, which occurs with 7 and 11 as a factor of 1001. The special advantage which proved of so much assistance in the case of $\frac{11}{9}$, $\frac{101}{99}$, etc., is therefore again available; and in this case will be applied to the first form of the general series. Here, on account of the difference of sign, the terms of the series have to be treated in two separate columns, and the letters a and b will be used for the sums of these partial series respectively.

$$\text{Log}\left(1 + \frac{1}{1000}\right) = \frac{M}{1000}\left\{1 + \frac{1}{3\cdot 1000^2} + \frac{1}{5\cdot 1000^4} + \text{etc.}\right\}$$
$$= M\left\{\frac{1}{2\cdot 1000^2} + \frac{1}{4\cdot 1000^4} + \text{etc.}\right\}$$

The work begins, as once before, with the middle column.

0. 43429 44819 032	1	0. 43429 44819 032 +		
01447 648	3	04342 944 +	2	0. 00000 02171 472
001	5	004	4	001
0. 43429 46266 681		a + b=0. 00043 45117 740		b= 0. 00000 02171 473
a=0. 00043 42946 267		a—b=0. 00043 40774 794		

log 1001=3 + a — b =	3. 00043 40774 79	log 999=3—a — b =	2. 99956 54882 26
log 77 =log 7 + log 11=	1. 88649 07251 72	log 27=3 log 3=	1. 43136 37641 59
log 13=	1. 11394 33523 07	log 37 =	1. 56820 17240 67

Thus the logarithm of 37, as previously that of 101, has presented itself as a by-product in the course of computing the logarithms of primes as far as 13.

With these logarithms as a basis, obtained mostly by methods especially adapted to them individually, it is now practicable to develop a more general plan, capable of being carried to any desired extent of succeeding primes. The principle is illustrated in the foregoing computation of log 7. In that case it was observed that three successive numbers of the natural series, 98, 99, 100, were made up of prime factors whose logarithms had been already found, with the single exception of the factor 7. Such a succession of three numbers I will call a *trio*. If the numbers constituting a trio be $a-1$, a, $a+1$, it is plain that a^2-1 and a^2 will be a pair of numbers involving the same prime factors, and differing by a unit. And if in the prime factors only one was new, then the logarithm of $\frac{a^2}{a^2-1}$, when found, will make that of the new factor also known. The general series, in the second form, is adapted to this purpose by putting $x = \frac{1}{2a^2-1}$; and $\frac{2M}{2a^2-1}$ is the approximate value of the logarithm, when only one term of the series is used. Succeeding terms are obtained by applying the divisors, 3, 5, etc., to the terms of a geometrical progression which begins with the value of the first term as just stated, and has for its common ratio $\frac{1}{(2a^2-1)^2}$ or $\frac{1}{4a^4-4a^2+1}$. The convergence of the series is more rapid than that of the progression, but approaches the rate of the latter as a limit; hence it is roughly correct, in estimating the number of places of decimals which will be yielded by a given number of terms of the series, to reckon that each term has to the preceding approximately the ratio of 1 to four times the fourth power of the middle number of the trio. Thus in the computation of log 7 above, the first figure of the first term was 4 in the fifth place of decimals, and that of the second was 4 in the fourteenth. The actual ratio was about $\frac{1}{10000000000}$ while that indicated by the foregoing estimate, (to which succeeding terms would more nearly conform) would be $\frac{1}{4}\cdot\frac{1}{994}$ or about $\frac{1}{4000000000}$. Thus in using this test there is no danger of exaggerating the convergence of the series, unless the number of places to be embraced in the computation is very great, extending into hundreds.

The selection of the most convergent series implies, accordingly, a search for trios; and to make this search systematically it is convenient to employ a factor table of a somewhat unusual construction. In the ordinary factor tables it is customary to find set down against each composite number its *lowest* factor; here the *highest* factor is the one required. Such a table is made with very little trouble beyond the mechanical labor of writing down the numbers. The highest factor of each number of the first hundred or so can of course be set down without calculation; and when the the table has been begun, it can be carried on to any extent by the following process. (For convenience, the part already written out may be called the first page, and the proposed extension the second page, but these parts may be of any length, and in any convenient ratio, one to the other.) The two pages are supposed to be ruled in pairs of columns, the first column containing the natural numbers in order, the last number on the first page being m and the last on the second, n. The second column is intended for the highest factor of each, and is full on the first page, empty on the second. Begin by writing the figure 2 in the second column against all the powers of 2 between m and n. These numbers will be obtained by doubling all those numbers between $\frac{1}{2}$m and m, which are marked with 2 on the first page, and continuing this operation, if m is less than $\frac{1}{2}$n, until the latter limit is reached. Then take up 3 and mark with this figure the products by three of all those numbers, from $\frac{1}{3}$m to $\frac{1}{3}$n, which are marked with either 2 or 3. Next set in 5 where it belongs, multiplying such numbers from $\frac{1}{5}$m to $\frac{1}{5}$n as are marked with 5 or any lower figure, that is, 2, 3 or 5. So proceed from one prime to another until the last prime smaller than $\frac{1}{2}$n has been used. The numbers remaining unmarked in the second page are primes, and the remaining gaps in the second column are therefore filled by writing in each the number to which it stands opposite in the first. The following is a fragment, from 1001 to 1060, of such a table as has been described:

1001	13	1011	337	1021	1021	1031	1031	1041	347	1051	1051
1002	167	1012	23	1022	73	1032	43	1042	521	1052	263
1003	59	1013	1013	1023	31	1033	1033	1043	149	1053	13
1004	251	1014	13	1024	2	1034	47	1044	29	1054	31
1005	67	1015	29	1025	41	1035	23	1045	19	1055	211
1006	503	1016	127	1026	19	1036	37	1046	523	1056	11
1007	53	1017	113	1027	79	1037	61	1047	349	1057	151
1008	7	1018	509	1028	257	1038	173	1048	131	1058	23
1009	1009	1019	1019	1029	7	1039	1039	1049	1049	1059	353
1010	101	1020	17	1030	103	1040	13	1050	7	1060	53

To make the series as convergent as possible, the trios are sought as far on in the table as they can be found, unless some specific purpose overrules this consideration. At the present point in the computation, logarithms have been found for all primes up to 13, but no series has been computed for the purpose of an independent check since the calculation of the modulus. An examination of the factor table indicates the trio 350, 351, 352 as suitable for this purpose, the factors of these three numbers being $2 \cdot 5^2 \cdot 7$, $3^3 \cdot 13$, $2^5 \cdot 11$. For the logarithms of primes above 13, it will be possible, now that those of 37 and 101 are available, to employ in every case a trio of numbers not less than 1000. This implies, as just shown, that the first term of the series will begin as low as the seventh place of decimals, while the second term will make its appearance not above the nineteenth place. Two terms of the series will be amply sufficient for all calculations in which accuracy to twenty-five places or less is required, and probably would answer, if used carefully, for thirty places. The *Tables du Cadastre* were computed to fourteen places with the intention that only twelve should be published, but it is said that the twelfth figure is untrustworthy.

The number of trios available for calculation increases as the work proceeds, so that there is usually no difficulty in finding one suitable for checking the results to a given point. For instance, the computation beyond the logarithm of 13 may be begun by finding that of the next prime from the trio 1715, 1716, 1717; which for brevity may be written [1716], the middle number being bracketed to represent all three. Then, as a check on the logarithms of 17, 37 and 101, that of 19 may be computed twice, using respectively the trios [1444] and [1616].

While keeping in general to the natural order of primes, an advantage may occasionally be gained by transpositions of it. Thus 23 is the next largest prime, but if log 29 be first calculated by the very convergent series derived from the trio [9801], then there is available for log 23 the trio [2001], recommended by the favorable form of the divisors.

In the search for trios in the factor table, it happens not infrequently that four or sometimes even five numbers are found in succession, each composed of factors small enough to be serviceable. There seems however to be no way of utilizing these conjunctions for the increase of the convergency. In the case of five, the products a^2-4, a^2-1 and a^2 do not form a new and higher trio. The number of available trios is indeed increased, for a quartet supplies three. If its component numbers be called a—1, a, b, b+1, (when b—a=1). then $(a-1)\ (b1) = a+b-(b-a)-1 = ab-2$. Hence $\frac{1}{ab-1}$ may be used for x in the series, but the conver-

NOTE.—In the second line from the bottom of this page, the formula should read

then $(a-1)\ (b+1) = ab-(b-a)-1 = ab-2$.

gence is lower than that of the two series derived from [a] and [b]. A quintet is equivalent to five trios, two of them inferior. Again, a series might conceivably be derived from an expanded trio, of the form a—2, a, a + 2. (Here a must be odd, else the three numbers would be merely doubles of those composing an ordinary trio.) The convergence of the series would in this case be impaired by a multiplier, 2 or 4, occurring in the numerators. On the whole, I have not found any instance where an actual advantage in computation has appeared to be derivable from any other form of concurrence in the factor table beside the trio.

In some cases, however, the trio permits of being fortified to great advantage by other means. For instance, if the trio be [a], and if it happen that $a^2 + 1$ breaks up into factors sufficiently small, then the numbers $a^2 - 1$, a^2, $a^2 + 1$ form a new trio, and the convergence is greatly increased, the variable x now having the value $\frac{1}{2a^4 - 1}$ instead of $\frac{1}{2a^2 - 1}$. An instance is afforded in the case of the logarithm of 29, the highest prime thus far included in our computation. Here the trio [99] had been used in the computation of log 7; but it was observed that $99^2 + 1$ or 9802 contains no factor above 29, hence log 29 is calculable by means of [9801].

That no instance of this kind might escape observation, the values of $a^2 + 1$, for successive integral values of a, were arranged in a table, each with its highest factor. An interesting property at once became apparent. If m be a factor of any number of the form $a^2 + 1$, then it is a factor of the mth number preceding or following, that is, of $(a \pm m)^2 + 1$. For the latter number consists of two parts $(a^2 + 1) + (m^2 \pm 2am)$, each divisible by m. Hence, since the proof is the same for $(m - a)^2 + 1$, it follows that the column of numbers of the form $a^2 + 1$ will contain two series of numbers divisible by m, the members of each series being m numbers apart, and there will be no multiples of m outside these series. Thus the fifth number, $5^2 + 1$, is divisible by 13. Then multiples of 13 are to be found at the eighteenth, the thirty-first, etc., (thus $18^2 + 1 = 13 \cdot 25$, $31^2 + 1 = 13 \cdot 74$ etc.); and also, (since $13-5=8$,) at the eighth, the twenty-first, etc. ($8^2 + 1 = 13 \cdot 5$, $21^2 + 1 = 13 \cdot 34$ etc.); but, besides these, no number of the form $a^2 + 1$ will be divisible by 13. For no multiple of 13 can come in at a distance down the column, say at the pth number, unless the (p—13)th number were also divisible, and so on back in a third series, headed by some number short of the 13th: but inspection of the first thirteen numbers shows that no such third series exists. Again, there are many primes that cannot be factors of any number of the form $a^2 + 1$. For instance, the first seven numbers of this form, 2, 5, 10, 17, 26, 37, 50, contain no multiple of 7, hence 7 cannot be a factor of any succeeding number. The same is true of 3, etc., etc. Accordingly, the factors of the numbers in this table are written out with ease, using the method of "Eratosthenes' sieve;" and whenever a number $a^2 + 1$ is seen to be composed of small factors only, the factors of a, a—1, and a+1 are to be compared. If these are also small, the trio $[a^2]$ is available for the computation of the logarithm of the largest of them.

A considerable number of valuable trios of the form $[a^3]$ can also be obtained. For this purpose a table is required of numbers of the form $a(a+1)+1$. The column composed of such numbers is found to have precisely the same properties in respect to the occurrence of prime factors as in the case of $a^2 + 1$, demonstrated in the same way. Thus the smallest number of this form to contain a factor 19 is the 7th. Multiples of 19 therefore appear in the 26th, 45th, etc., places, and also in the 11th, 30th, etc., but nowhere else. No number of the present form can be divided by 2, 5, 11, etc. To use this table for the discovery of a trio of the form [a^3], two successive numbers must be found whose highest prime factor does not exceed the number whose logarithm is to be computed. Let these be b(b+1)+1 and a(a+1)+1 respectively, where a=b+1. Then the former of the two might also be expressed as a(a—1)+1. Accordingly, if the factors of a—1, a, and a+1 do not exceed the proposed limit, it follows that $(a-1)(a^2+a+1)$, or a^3-1 is divisible into the same small factors, and the same is true of a^3 and a^3+1. For instance, opposite the arguments 25 and 26 in the table are found the numbers 651, 703, whose highest factors are 31 and 37. As log 37 has been computed, while the numbers 25, 26, 27 obviously contain no factor higher than 31, the trio [17576], whose middle number is the cube of 26, is available for the computation of the logarithm of 31.

While trios of the forms [a^2] and [a^3] are very powerful when they can be employed, their range of applicability is regrettably limited, as may be inferred from the large number of primes excluded from each of the auxiliary tables. To utilize as many as possible, it is necessary that the order in which the logarithms of the primes are computed should frequently deviate from that of the primes themselves in the natural series. For instance, the trio [5830], which involves the factors 53 and 67, might have been used for the logarithm of the larger of these numbers, some inferior trio being employed for 53; but a trio of the form [a^3], viz. [314432], involving no other factor above 31, is furnished by the auxiliary table for the computation of log 67; so that this latter is to be used first, and then log 53 can be found from [5830].

A list of trios which may be employed for the logarithms of primes from 41 to 109, inclusive, will be found below. (Those of the lower primes have all been discussed in the foregoing text.) It may be noted that the most advanced of these, [4019679], produces a series so convergent that while the first term begins with the figure 2 in the fourteenth place, the next will enter at the fortieth place of decimals.

For 41, the trio [8281] may be employed, composed of the numbers whose prime factors are $2^3 \cdot 3^2 \cdot 5 \cdot 23$, $7^2 \cdot 13^2$, $2 \cdot 41 \cdot 101$.

For 67, [314432]; $13 \cdot 19^2 \cdot 67$, $2^6 \cdot 17^3$, $3^2 \cdot 7^2 \cdot 23 \cdot 31$.
For 43, [50653]; $2 \cdot 3^3 \cdot 7 \cdot 67$, 37^3, $2 \cdot 19 \cdot 31 \cdot 43$.
For 47, [6579]; $2 \cdot 11 \cdot 13 \cdot 23$, $3^2 \cdot 17 \cdot 43$, $2^2 \cdot 5 \cdot 7 \cdot 47$.
For 53, [5830]; $3 \cdot 29 \cdot 67$, $2 \cdot 5 \cdot 11 \cdot 53$, $7^3 \cdot 17$
For 59, [13689]; $2^3 \cdot 29 \cdot 59$, $3^4\, 13^2$, $2 \cdot 5 \cdot 37^2$.
For proof, [3009]; $2^6 \cdot 47$, $3 \cdot 17 \cdot 59$, $2 \cdot 5 \cdot 7 \cdot 43$.
For 107, [5565]; $2^2 \cdot 13 \cdot 107$, $3 \cdot 5 \cdot 7 \cdot 53$, $2 \cdot 11^2 \cdot 23$.
For 109, [5886]; $5 \cdot 11 \cdot 107$, $2 \cdot 3^3 \cdot 109$, $7 \cdot 29^2$.
For 103, [97336]; $3^3 \cdot 5 \cdot 7 \cdot 103$, $2^3 \cdot 23^3$, $19 \cdot 47 \cdot 109$.
For 61, [103823]; $2 \cdot 23 \cdot 37 \cdot 61$, 47^3, $2^4 \cdot 3^2 \cdot 7 \cdot 103$.
For 71, [20164]; $3 \cdot 11 \cdot 13 \cdot 47$, $2^2 \cdot 71^2$, $5 \cdot 37 \cdot 109$.
For 73, [262144]; $3^3 \cdot 7 \cdot 19 \cdot 73$, 2^{18}, $5 \cdot 13 \cdot 37 \cdot 109$.
For proof, [5184]; $71 \cdot 73$, $2^6 \cdot 3^4$, $5 \cdot 17 \cdot 61$.
For 79, [175616]; $5 \cdot 11 \cdot 31 \cdot 103$, $2^9 \cdot 7^3$, $3^2 \cdot 13 \cdot 19 \cdot 79$.
For 89, [8990]; $89 \cdot 101$, $2 \cdot 5 \cdot 29 \cdot 31$, $3^5 \cdot 37$.
For proof, [6320]; $71 \cdot 89$, $2^4 \cdot 5 \cdot 79$, $3 \cdot 7^2 \cdot 43$.
For 83, [10126]; $3^4 \cdot 5^3$, $2 \cdot 61 \cdot 83$, $13 \cdot 19 \cdot 41$.
For 97, [4019679]; $2 \cdot 13 \cdot 19 \cdot 79 \cdot 103$, $3^3 \cdot 53^3$, $2^5 \cdot 5 \cdot 7 \cdot 37 \cdot 97$.
For proof, [8051]; $2 \cdot 5^2 \cdot 7 \cdot 23$, $83 \cdot 97$, $2^2 \cdot 3 \cdot 11 \cdot 61$.

While it is not claimed that in every case the most favorable series has been discovered, it is believed that as a whole the scheme as here outlined furnishes an easy means for the preparation of a basis, upon which, by a method of differences, a table extended to a greater number of places than any yet in use might be founded.

A table of the logarithms of the primes, as far as above indicated, is subjoined.

Colorado College Observatory, January, 1907.

Logarithms of Primes below 110 to Eighteen Places.

2,	0.301029 995663 981195
3,	0.477121 254719 662437
5,	0.698970 004336 018804 +
7,	0.845098 040014 256830 +
11,	1.041392 685158 225040 +
13,	1.113943 352306 836769
17,	1.230448 921378 273928 +
19,	1.278753 600952 828961 +
23,	1.361727 836017 592878 +
29,	1.462397 997898 956087
31,	1 491361 693834 272679 +
37,	1.568201 724066 994996 +
41,	1.612783 856719 735494 +
43,	1.633468 455579 586526
47,	1.672097 857935 717464
53,	1.724275 869600 789045 +
59,	1.770852 011642 144190
61,	1.785329 835010 767033 +
67,	1.826074 802700 826434
71,	1.851258 348719 075286
73,	1.863322 860120 455901
79,	1.897627 091290 441427 +
83,	1.919078 092376 073903 +
89,	1.949390 006644 912784 +
97,	1.986771 734266 244851 +
101,	2.004321 373782 642574
103,	2.012837 224705 172205
107,	2.029383 777685 209640 +
109,	2.037426 497940 623635

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SEMI-ANNUAL BULLETIN

OF THE

COLORADO COLLEGE OBSERVATORY

CONTAINING THE

Annual Meteorological Summary

FOR 1906.

F. H. LOUD, PH. D. Director.

COLORADO SPRINGS, COLORADO

JULY, 1907

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SCIENCE SERIES.

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" 13. The Origin and Use of the Natural Gas at Manitou, Colorado (one plate).—*Wm. Strieby.*

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" 20. Preliminary Notice of Three Late Neocene Terranes of Kansas.—*F. W. Cragin.*

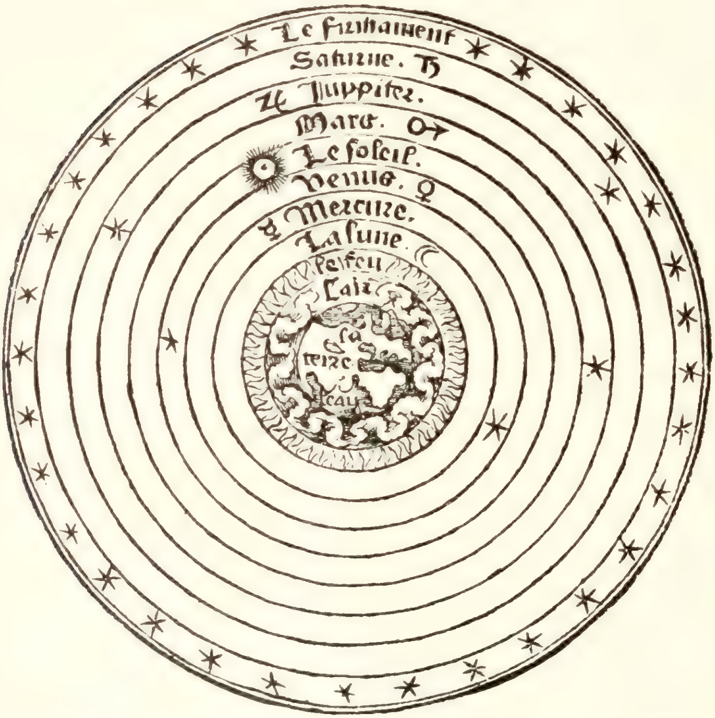
" 21. Warming Up.—*E. G. Lancaster.*

" 22. Equations of Motion of Viscous Liquid (Part I).—*P. E. Doudna.*

" 23. Equations of Motion of a Perfect Liquid and a Viscous Liquid. When Referred to Cylindrical and Polar Co-ordinates (Part II), —*P. E. Doudna.*

(Continued on inside of back cover.)

Description & distinction des orbes celestes.



A diagram by Oronce Fine, setting forth the Ptolemaic system of the world.

Since the appearance of this statistical bulletin for 1905, three persons, who have been named in all of the annual numbers of the series, in just recognition of the indebtedness of the Observatory to each, have been removed by death;— Dr. S. E. Solly, on November 18, 1906; Mr. Charles S. Blackman, on December 20, 1906; and Mr. Charles D. Child, on February 26, 1907.

Samuel Edwin Solly was born in London, England, May 5, 1845; and died in Asheville, N. C., in the sixty-second year of his age, leaving a widow (formerly Mrs. Elizabeth Mellor Evans, of Philadelphia, Pa.), and two daughters by a former marriage in London, to Miss Alma Helena Sandwell, who died in 1875. His father, Samuel Solly, F. R. S., was an eminent surgeon and author, while his grandfather, Isaac Solly, of Leighton House, Essex, is remembered as the first chairman of the first great railroad in England, the London and Birmingham. Among the ancestors of his mother's family, were the Majors of Hursley, from whom Oliver Cromwell took a wife for his eldest son. Educated at Rugby School, and St. Thomas Hospital Medical College, Dr. Solly first practiced medicine in London, assuming the practice of his father, who died in 1871; but in 1874 he was forced by ill health to remove to Colorado, and at once took a leading part in the "Fountain Colony," the newly launched enterprise out of which has grown the city of Colorado Springs. In the thirty-two years during which this was his home, his professional eminence, and his rare personal and social qualities won for him the highest regard, and numerous honors, both local and national, among which may be mentioned the presidency of the County and State Medical Societies, and of the American Climatological Society. He was the author of "A Handbook of Medical Climatology," published by Lea Brothers & Co., 1897, and of several medical treatises and numerous essays. He was always a warm and active friend of the meteorological work carried on at Colorado College. The set of Draper instruments secured by him for the latter in its early history, was purchased from the proceeds of a series of entertainments, which included a lecture by Miss Emily Faithful, of England, and possibly others, but mainly consisted of dramatic renderings, in which he was a leading participant as well as sole organizer and manager. In later years he never failed to give the support of hearty interest and wise counsel.

Charles Seymour Blackman, who was the son of Alfred Blackman, and grandson of Samuel Curtis Blackman, both noted jurists of Connecticut, was born in Humphreysville, in that state, March 29, 1837. Like his father and grandfather, he was an alumnus of Yale, the three having been graduated in the classes of 1793, 1828, and 1857. While in college, he was captain of the boat crew, leader of the orchestra, and a member of the "Skull and Bones." He was much interested in science, particularly in astronomy, a predilection which was maintained through life. He had a passion for work, in a wide variety of lines, but especially enjoyed mechanics of the precise order involved in the construction and adjustment of astronomical instruments. He was skilled in the mechanism of clocks and watches. During the greater part of his stay in Montreal, Canada, (which he made his home from the year 1858, and where he died) he had charge of the time-service of McGill University, furnishing the time used by the Grand Trunk Railway, and by the city of Montreal and a large section of Canada. In 1880 he presented McGill Observatory with a telescope, a transit, and other instruments. The clock which, together with a smaller transit, he gave to the Observatory of Colorado College, was largely his own handiwork, and therein the better proof of a personal interest often manifested and deeply appreciated.

Charles Daniel Child, born April 6, 1875, was of English nativity, his family home being in Southport, Lancashire. His removal to Colorado, which was prompted by considerations of health, at first appeared to have successfully accomplished its object. His marriage to Miss Emily Price, a native of Askeaton, county Limerick, Ireland, proved of the utmost value in the years of decline which so soon followed, when, as a consequence of relapse brought on by over exertion, his disease hastened to its fatal termination in his thirty-second year. In 1904, at the suggestion of Dr. Solly, Mr. Child took up the work of reduction of the observations and instrumental records connected with the College meteorology, and at once proved himself able to render very important service by reason of his careful methodical procedure, guided by a native love of accuracy. These qualities, together with his loveable temperament and brave, cheerful disposition, made him a highly valued co-worker, whose loss will not soon cease to be deplored.

METEOROLOGICAL STATISTICS FOR 1906.*

By F. H. Loud.

Building, Equipment, and Exposure of Instruments.

The Observatory building of Colorado College, erected in 1894, the gift of Henry R. Wolcott, Esq., of Denver, is in latitude 38 deg., 50 min., 44 sec.; longitude 6 hrs., 59 min., 16.5 sec.; elevation about 6,040 feet; (all of these figures are obtained by reference to neighboring stations of United States surveys.)

The astronomical equipment consists of a four-inch equatorial telescope, given to the College by the donor of the building, and a transit instrument and clock, given in 1900 by the late Charles S. Blackman, of Montreal, Canada.

The meteorological equipment in part antedates the building, the nucleus having been obtained from the U. S. Signal Service, when the college first became a voluntary weather station in 1878. Several additions of apparatus were subsequently made. Much the most noteworthy, during the earlier years, was that of a set of Draper self-recording instruments, due to the generous interest of the late Dr. S. E. Solly, of Colorado Springs, who was seconded by Mr. B. W. Steele, editor of the "*Gazette*," in his lifetime one of the staunchest advocates of local enterprises in science, and by other friends. Of these Draper instruments, the barograph alone remains in use. In November, 1903, the quadruple register with all the apparatus connected with it, together with a number of other instruments, especially hygrometers of different kinds, were

* The matter introductory to the tabulated statistics, presented under this head, is in the main reprinted from the Colorado College Publication (General Series No. 16) which appeared in April, 1905. A somewhat more detailed account than is here given of the process used in preparing the Daily Record sheets from the instrumental data may be found in that issue. In the number for October, 1904, is contained a more extended description of the meteorological instruments, including an untechnical account of the principles of their construction.

given by General William J. Palmer, who has since provided for the expense of reducing and publishing the observations and records.

The exposure of instruments pertaining to wind, sunshine and temperature is on the roof of Hagerman Hall, a building standing east of the Observatory and on higher ground. Here is the standard thermometer shelter, 10 feet above the roof, 54 feet above the ground and 69.5 feet above the level of the Observatory floor. It contains maximum and minimum thermometers, a whirling psychrometer, and a Richard thermograph. Higher by 7 feet, and at horizontal distances of 11 feet from the shelter and 341 feet from the Observatory door, is the wind vane, on the iron support of which are attached the Robinson anemometer and the electric sunshine recorder. The cable connecting these three instruments with the quadruple register in the Observatory is laid underground.

Near the middle of the flat roof of the Observatory, which affords, on the east side of the dome, a clear space 37 feet long (east and west) and 27½ feet broad, and is 16 feet above the ground, is the rain gauge, provided with a tipping-bucket attachment for registration. It is electrically connected with the quadruple register, which is in the same building, on the first floor. Here, also, on the north side, is a window shelter for the exposure of the hygrometric apparatus, exclusive of the whirled psychrometer. This consists of a Richard registering psychrometer, a dew point apparatus, and a hair hygrometer. The Draper barograph is on the south wall of the same room, but the barometer read at the tri-daily observations, as well as the Richard barograph, is in the upper story of Hagerman Hall, at an elevation exceeding that of the Draper instrument by 43.2 feet.

THE "DAILY RECORD."

The summaries for the months, which are presented in tabular form in the pages following, are derived in the main from a prior set of tables, one for each day, called the Daily Record, which is preserved in MS. form, along with the original sources, at the Observatory. In the Daily Record is tabulated first, the wind-direction, the register of which, as automatically made upon the instrument, consists of four rows of dots, for N., E., S., and W., made at intervals of one minute. The count of dots in the four rows, for each hour of the day, occupies the beginning of the record, followed by the *mean bearing* for that hour, deduced from the preceding by a specially adapted traverse table. Next is the hourly wind-velocity, obtained by counting the anemometer record. Succeeding columns exhibit the resolution of this velocity into two components determined by the bearing, one directed along the meridian and the other at right angles thereto.

After the wind-record come the two other data derived from the Quadruple Register, viz.: the rainfall and sunshine, for hourly periods, and after these the pressure as shown by the trace of the Draper barograph at the end of the hour. The temperature, which is next on the record, is obtained from the Richard thermograph, by noting the highest and lowest indications in the course of each hour, and taking the half sum of these as the mean hourly temperature. The humidity records and those on the state of the sky, whether "clear," "partly cloudy," or "cloudy," are taken from the tri-daily observations.

The foregoing data can in large part be obtained from supplementary sources in case the record of the instrument ordinarily used should for any reason be temporarily unavailable. Thus, if a gap occurs in the Draper register of pressure, it can be filled from the Richard barograph with a suitable correction for difference of elevation. The sunshine record is similarly supplemented by the indication of a photographic instrument, of a design originating at the Harvard College Observatory, and belonging to the station of the Western Association for Stellar Photography, at Knob Hill, about two miles east of the College grounds. A small anemometer register at Hagerman Hall is actuated by the same electric current which goes to the corresponding pen in the larger instrument at the Observatory. An interesting term of comparison with the College observations is afforded by those of Mr. Emery P. Moon, who kindly furnishes daily readings of maximum and minimum thermometer and rain-gauge, made about a mile east of the College at 222 Cedar Street.

Except in the case of the Hagerman Hall anemometer, the sources of supplementary data above named are quite different from the primary ones, either as respects construction or exposure of instruments, and hence discrepancies between the parallel records are continually presented, which often throw additional light upon the actual physical conditions recorded. In the case of the sunshine record, these discrepancies often overpass the limit of desirable divergency, and sometimes to such an extent that the two simultaneous records can hardly be believed to belong to the same day. Yet insofar as this disagreement is due to the two-mile interval between the points of exposure, it is likely that the conditions of cloud and sunshine, quite diverse for particular parts of the day, would show better agreement in the daily sums. Each instrument is defective in its account of the sunshine in the morning hours, but it is not the practice here, as at some other stations, to make allowance for this by adding an arbitrary correction.

THE "MONTHLY SUMMARY" AND OTHER TABLES.

The manner of deriving the tables annually printed from the MS. "Daily Record" requires little explanation. The first column, "Mean Temperature for Twenty-four Hours," is the mean of the hourly temperatures. The "Extremes" are the readings of the maximum and minimum thermometers, and are hence independent of the thermograph, whose indications will, of course, frequently fall short of the limits of range. The "Hours of Extremes," on the other hand. are taken from the Richard instrument. The numbers in the six columns under "Psychrometer" are the results each of a single observation, merely transferred from the daily sheet. The "Clouds at Observation" are the sums of the three daily estimates, and as each of the latter range from 0 to 10, the cloudiness of the day is here represented on a scale of 30. The "Number of Minutes Actual Sunshine" is again the sum of a column in the Daily Record. The "Possible Sunshine" in the next column is the length of time the sun could be seen if unclouded, as determined by a survey of the line of mountain tops in the western horizon, described in an article which first appeared in "Colorado Weather," and was reprinted in the Colorado College Publication for October, 1904. The column "per ct." at the end of the page, gives, of course, the ratio of the numbers in the two columns preceding.

The column headed "Barometer, Actual Pressure at 12 M." is from the eye-observation at noon. The "Total Velocity of Wind," is from the sum of the hourly numbers in the Daily Record, checked by the dial-readings of the anemometer. Under the "Sum of Components," are given the footings of the four columns headed "Velocity Resolved" in the Daily Record. From these are deduced trigonometrically the "Equivalent" in direction and number of miles of resultant movement. Finally, under "Rain Gauge," are given the times of ending of the hours during which the first and last precipitation for the day occurred, together with the total daily amount.

The "Annual Summary, by Months," which directly follows the monthly summaries, is entirely composed of material drawn from the latter, and its construction is believed to be self-explanatory.

As in the preceding annual publications of statistics, for 1904 and 1905, a page is devoted to the mean hourly values of sunshine (as given by the electric recorder), pressure (from the Draper barograph) and temperature (from the Richard thermograph) for the four months of January, April, July and October. This table, in the present number precedes the monthly summaries, page 355.

The footnotes appended to the several tables indicate, among other things, the cases in which it has been necessary to make up a mean from an incomplete record. The instances in which an imperfect record of sunshine, taken from the electric instrument, has been supplemented by means of the Knob Hill photographic register, are not of importance this year, except in the case of the month of October, which has been wholly taken from Knob Hill. The batteries furnishing the current for the quadruple register exhibited signs of enfeeblement toward the end of the first half of the year. A plan for replacing them in the fall by a different kind was then under consideration; and accordingly temporary expedients were adopted in June, with the loss of but a few hours of the record of that month. In July, however, during the absence of the instructors and students best acquainted with its working, the battery took occasion to break down completely; and as a consequence, the record of wind direction is so defective for that month that it has been deemed best to omit it altogether. The battery was renewed in the old form, without the change at first contemplated.

Until within a few weeks of the lamented death of Mr. C. D. Child, noted on an earlier page, he continued to do some work in computation for the present bulletin. Later, the director has been aided in its compilation by a number of different assistants. In the work of observation and care of the instruments, Mr. C. N. Angell has continued to act as heretofore, with Messrs. Silmon L. Smith and T. D. Riggs, students in the College.

MEAN DAILY MARCH OF ATMOSPHERIC CONDITIONS 1906.

Hour Ending.	January.			April.			July.			October.		
	Sun.	Barom.	Therm.	Sun.	Barom.	Therm.	Sun.	Barom.	Therm.	Sun.	Barom.	Therm.
1 A. M.	......	23.962	27.5	......	23.991	40.3	......	24.163	56.8	......	24.067	3.94
2 "	......	.964	28.5	......	.983	39.8	......	.158	55.7	......	.062	38.9
3 "	......	.964	28.2	......	.982	39.1	......	.157	54.9	......	.056	37.9
4 "	......	.962	28.1	......	.982	38.1	......	.159	54.1	......	.056	38.1
5 "	......	.959	27.8	......	.981	37.2	......	.162	53.5	......	.059	38.1
6 "	......	.965	28.1	......	.989	37.6	......	.165	54.0	......	.065	37.9
7 "	......	.975	28.1	12	.998	39.6	......	.169	56.9	1	.072	38.8
8 "	......	.984	27.9	22	24.001	43.0	7	.169	61.3	35	.078	42.0
9 "	24	.995	29.4	38	.001	47.3	25	.166	65.1	44	.079	46.6
10 "	38	.999	33.9	46	23.995	48.3	30	.164	67.4	45	.077	51.1
11 "	41	.992	38.3	46	.989	50.0	41	.160	69.1	45	.069	53.0
12 M.	42	.974	40.5	45	.979	51.4	35	.153	69.7	46	.055	54.2
1 P. M.	43	.952	41.5	45	.968	51.9	31	.145	70.0	39	.034	55.0
2 "	44	.945	42.1	42	.962	52.0	27	.142	70.6	43	.025	55.9
3 "	42	.951	42.2	41	.954	52.4	18	.141	69.6	44	.020	56.4
4 "	37	.960	41.5	39	.955	52.7	15	.138	69.1	42	.021	56.0
5 "	12	.970	39.4	31	.958	52.6	13	.141	68.2	29	.027	54.3
6 "	......	.980	36.1	20	.961	51.4	6	.141	67.5	1	.037	51.1
7 "	......	.987	32.5	......	.971	49.6	......	.145	66.2	......	.048	48.0
8 "	......	.995	30.1	......	.991	46.9	......	.152	63.9	......	.056	45.7
9 "	......	.998	28.4	......	.999	45.2	......	.163	61.8	......	.065	43.4
10 "	......	.995	28.0	......	24.001	43.8	......	.166	60.1	......	.065	41.6
11 "	......	.992	27.7	......	.001	42.7	......	.167	58.8	......	.063	40.4
12 n't	......	.981	27.4	......	.003	41.5	......	.165	57.6	......	.061	39.9
Sums,	323	575.404	783.2	427	575.595	1091.1	218	579.751	1501.9	414	577.317	1103.7
Means,	......	23.975	32.6	......	23.983	45.6	......	24.156	62.6	......	24.055	46.0

MONTHLY SUMMARY OF

JANUARY,

DATE.	THERMOMETERS.					PSYCHROMETER.						SUNSHINE RECORD			
	TEMPERATURES.			Hours of Extremes.		Relative Humidity.			Dew-point.			Clouds at Observ'n.	Number of Minutes.		P
	Mean of 24 h.	Extremes. Max.	Extremes. Min.	Max.	Min.	6 A.M.	12 M.	6 P.M.	6 A.M.	12 M.	6 P.M.		Actual.	Possible.	c
1	19.9	26	14	3 p.m.	12 n't	72	65	85	11	15	14	21	....	529	..
2	16.1	22	13	5 p.m.	6 a.m.	90	86	72	13	15	11	23	0	529	
3	21.0	26	7	2 p.m.	8 a.m.	66	55	88	5	12	19	15	.....	530	..
4	39.1	48	25	1 p.m.	9 p.m.	30	29	51	13	18	20	10	....	530	..
5	37.9	49	19	3 a.m.	12 n't	13	21	52	0	9	18	0	476	532	8
6	34.1	49	16	11 a.m.	3 a.m.	31	19	44	11	28	18	9	379	532	7
7	29.7	45	14	3 a.m.	12 n't	37	51	87	14	20	18	20	66	533	
8	16.1	33	0	2 p.m.	8 a.m.	95	38	65	1	11	15	0	435	533	8
9	28.2	49	14	4 p.m.	6 a.m.	51	16	41	8	7	15	0	...	535	..
10	29.9	47	16	2 p.m.	2 a.m.	62	24	70	11	14	29	16	.....	535	..
11	27.1	40	16	2 p.m.	8 a.m.	55	54	59	3	23	19	11	194	536	3
12	40.0	50	25	2 p.m.	1 a.m.	67	40	45	26	25	22	17	224	536	
13	44.4	53	36	4 p.m.	1 a.m.	58	26	49	28	16	28	9	458	538	
14	42.2	52	29	1 p.m.	7 p.m.	59	14	80	29	6	25	15	.....	539	..
15	31.1	41	20	3 p.m.	12 n't	49	46	41	13	19	15	5	480	541	
16	32.1	49	17	4 p.m.	8 a.m.	73	32	71	12	15	31	5	315	541	
17	47.9	57	32	4 a.m.	12 n't	30	25	28	21	20	16	10	448	543	
18	43.8	62	26	4 a.m.	7 a.m.	57	28	45	15	25	30	14	407	544	
19	52.1	59	46	6 a.m.	8 p.m.	17	29	20	13	23	13	7	.....	546	..
20	30.0	48	10	1 a.m.	12 n't	34	63	72	17	22	11	18	.....	548	..
21	10.1	20	–2	1 p.m.	12 n't	66	46	55	4	3	3	1	.....	550	..
22	13.9	32	–1	3 p.m.	3 a.m.	73	78	49	5	21	7	0	465	551	
23	28.7	43	16	1 p.m.	8 a.m.	51	40	54	8	24	19	0	458	553	
24	38.0	50	23	12 m.	1 a.m.	41	40	57	26	27	27	16	218	555	
25	32.9	59	21	3 p.m.	6 a.m.	62	52	56	11	31	25	0	475	557	
26	37.6	59	24	3 p.m.	7 a.m.	71	37	34	22	31	23	0	497	558	
27	36.9	53	24	3 p.m.	8 a.m.	79	40	41	23	27	22	0	498	560	
28	33.5	50	20	3 p.m.	5 a.m.	75	40	46	16	25	19	0	478	562	
29	41.1	55	21	2 p.m.	12 n't	47	25	38	25	20	19	3	.....	564	..
30	32.8	50	20	3 p.m.	4 a.m.	63	35	50	12	22	24	0	502	566	
31	42.2	62	24	2 p.m.	1 a.m.	49	25	25	19	24	18	3	524	568	
Sums,	1010.4	1429	585	....	....	1723	1249	1670	435	628	593	248	.....	.....	1
Means,	32.6	46.1	18.9	....	....	56	40	54	14	20	19	8	.....	.....	..
Perctg.	...	...	...	....	....	...	...	...	...	...	...	27%	.....	.....	6

* For 21 da

INSTRUMENTAL RECORD.

1906.

BAROM.	ANEMOMETER AND ANEMOSCOPE.							RAIN GAUGE.			
	WIND.										
Actual Pressure at 12 M.	Total Velocity.	Sum of Components.				Equivalent.		Hours of Fall.		Total Amount.	Date.
		N.	S.	W.	E.	Direction.	Miles.	Earliest.	Latest.		
23.925	244	199.2	31.3	17.1	40.5	N. 7° 56′ E.	169.6	0	0	0	1
.702	257	205.3	1.6	136.1	6.6	N. 32° 27′ W.	241.4	....	1 p.m.	.41	2
.785	173	109.7	24.7	73.4	24.5	N. 29° 55′ W.	98.0	0	0	T	3
.887	380	279.1	9.9	206.2	22.5	N. 34° 19′ W.	325.9	0	0	0	4
24.100	181	118.5	27.9	51.5	39.9	N. 7° 18′ W.	91.3	0	0	0	5
.091	134	93.5	19.1	18.9	34.1	N. 11° 33′ E.	75.9	0	0	0	6
.155	246	222.4	7.2	22.6	31.2	N. 2° 17′ E.	215.8	0	0	T	7
.291	106	85.3	12.4	6.5	16.5	N. 7° 50′ E.	73.4	0	0	0	8
.035	164	113.8	28.7	5.9	40.8	N. 22° 18′ E.	91.9	0	0	0	9
23.904	194	123.8	32.6	31.6	31.9	N. 0° 11′ E.	91.2	0	0	0	10
24.129	111	65.1	18.7	14.0	38.1	N. 27° 27′ E.	52.2	0	0	0	11
23.788	187	102.0	5.5	138.4	2.5	N. 54° 37′ W.	166.7	0	0	0	12
.731	491	213.0	6.3	408.8	9.2	N. 62° 39′ W.	449.9	0	0	0	13
.517	406	123.1	122.8	281.5	5.1	N. 89° 56′ W.	276.4	0	0	T	14
.909	420	278.8	8.3	282.6	12.0	N. 45° 01′ W.	382.6	5 p.m.	8 p.m.	.01	15
.892	124	42.5	49.1	21.5	42.8	S. 72° 47′ E.	22.3	0	0	0	16
.743	411	156.9	7.6	358.4	0.6	N. 67° 21′ W.	387.7	0	0	0	17
.735	152	84.7	25.3	37.9	43.2	N. 5° 06′ E.	59.6	0	0	0	18
.421	708	......	......	......	......	....	......	0	0	0	19
.487	169	......	......	......	......	....	......	3 p.m.	5 p.m.	.03	20
24.007	101	97.1	0	17.9	8.1	N. 5° 46′ W.	97.5	0	0	0	21
.043	80	56.4	14.3	12.1	13.6	N. 2° 02′ E.	42.2	0	0	0	22
.219	93	64.0	17.3	11.9	19.3	N. 9° 00′ E.	47.3	0	0	0	23
.328	108	99.8	0	10.8	10.8	North	99.8	0	0	0	24
.385	114	82.7	19.7	9.8	21.5	N. 10° 31′ E.	64.0	0	0	0	25
.368	134	106.1	19.0	17.2	12.6	N. 3° 01′ W.	87.4	0	0	0	26
.338	122	93.3	17.5	5.9	22.5	N. 12° 21′ E.	77.6	0	0	0	27
.213	.....	......	......	......	......	....	......	0	0	0	28
.061	.....	......	......	......	......	....	......	0	0	0	29
.277	157	86.8	49.2	11.3	46.0	N. 42° 42′ E.	51.1	0	0	0	30
.227	142	102.8	26.9	18.2	20.9	N. 2° 02′ E.	76.0	0	0	0	31
743.693	6309	3405.7	602.9	2228.0	626.3	....	......	....	....	0.45	......
23.990	217.5†	......	......	......	......	....	......	....	....	....	......
....	....	......	......	......	......	....	......	....	....	....	......

† For 28 days.

MONTHLY SUMMARY OF

FEBRUARY,

DATE.	THERMOMETERS.					PSYCHROMETER.						SUNSHINE RECORD'			
	TEMPERATURES.			Hours of Extremes.		Relative Humidity.			Dew-point.			Clouds at Observ'n.	Number of Minutes.		
	Mean of 24 h.	Extremes. Max.	Min.	Max.	Min.	6 A.M.	12 M.	6 P.M.	6 A.M	12 M.	6 P.M.		Act-ual.	Pos-sible	Per ct
1	36.0	54	22	4 p.m.	7 a.m.	77	40	43	18	25	23	0	480	570	84
2	35.8	51	24	3 p.m.	8 a.m.	59	41	51	17	26	25	0	500	572	87
3	45.4	60	24	2 p.m.	12 n't	24	19	28	16	18	22	10	501	574	87
4	9.9	24	2	1 a.m.	12 n't	77	49	79	0	1	2	14	439	576	76
5	18.7	42	1	1 p.m.	5 a.m.	75	46	68	-5	19	19	3	509	578	88
6	19.2	33	9	3 p.m.	5 a.m.	60	70	67	1	21	17	0	465	581	80
7	28.2	42	12	2 p.m.	1 a.m.	62	25	48	11	10	17	0	521	583	89
8	26.5	40	13	3 p.m.	5 a.m.	44	29	60	1	9	18	0	523	585	89
9	23.1	43	6	3 p.m.	5 a.m.	79	37	38	3	14	11	10	392	587	67
10	18.2	30	8	4 p.m.	7 a.m.	81	60	57	6	10	15	6	475	590	8
11	32.9	48	16	5 p.m.	6 a.m.	66	22	30	16	11	13	2	521	592	88
12	33.8	48	20	2 p.m.	3 a.m.	57	35	49	15	22	22	17	286	594	48
13	22.2	38	10	1 a.m.	12 n't	77	78	85	20	21	13	24	130	595	2
14	17.3	33	5	5 p.m.	8 a.m.	69	79	89	1	22	26	9	269	597	4
15	28.4	47	12	2 p.m.	4 a.m.	70	41	59	9	22	23	16	266	599	4
16	37.7	49	24	3 p.m.	12 n't	55	26	47	24	14	21	13	490	602	8
17	32.9	51	15	3 p.m.	5 a.m.	72	30	31	11	21	16	16	401	605	6
18	33.2	51	18	4 p.m.	6 a.m.	73	33	35	12	20	19	0	542	609	8
19	37.7	60	21	1 p.m.	1 a.m.	64	12	26	13	11	16	13	464	612	7
20	34.9	52	18	4 p.m.	7 a.m.	73	17	13	14	7	0.	3	549	615	8
21	46.0	65	27	1 p.m.	1 a.m.	72	18	23	24	21	20	14	408	617	6
22	41.6	47	34	3 p.m.	12 n't	55	24	21	24	14	8	8	393	619	6
23	30.7	37	26	5 p.m.	8 a.m.	89	75	67	26	28	26	17	38	623	
24	32.7	47	16	3 p.m.	7 a.m.	60	21	25	10	8	10	9	553	627	8
25	37.8	53	22	2 p.m.	2 a.m.	48	20	29	11	13	14	1	516	628	8
26	31.6	43	22	3 p.m.	12 n't	54	4	22	11	-23	4	0	571	630	9
27	36.0	55	17	4 p.m.	5 a.m.	73	20	45	14	13	26	3	475	632	7
28	47.8	60	30	12 m.	1 a.m.	52	19	22	31	18	18	11	328	635	5
Sums,	876.2	1303	474	....	....	1817	990	1257	354	416	464	219	.....	.....	19
Means,	31.3	46.5	16.9	....	....	65	35	45	13	15	17	8	.....	.....	...
Perctg.	......	......	......	....	....	.....	.....	.....	.....	.....	.....	26%	.....	.....	7

INSTRUMENTAL RECORD.

1906.

Barom.	Anemometer and Anemoscope.							Rain Gauge.			
	Wind.										
Actual Pressure at 12 m.	Total Velocity.	Sum of Components.				Equivalent.		Hours of Fall.		Total Amount.	Date.
		N.	S.	W.	E.	Direction.	Miles.	Earliest.	Latest.		
24.289	119	95.9	13.5	11.5	18.9	N. 5° 08′ E	82.7	0	0	0	1
.326	164	72.0	62.3	6.6	65.8	N. 80° 45′ E.	60.2	0	0	0	2
23.889	320	242.4	0	171.5	9.2	N. 33° 48′ W.	291.7	0	0	0	3
24.210	288	128.4	107.8	11.5	136.4	N. 80° 38′ E.	126.6	0	0	T	4
.049	123	39.9	37.6	6.0	67.6	N. 87° 52′ E.	61.7	0	0	T	5
.171	150	61.1	58.3	3.5	64.9	N. 87° 23′ E.	61.5	0	0	0	6
.101	193	76.4	78.1	18.0	77.6	S. 88° 22′ E.	59.6	0	0	0	7
.055	208	124.6	33.8	12.7	101.1	N. 44° 14′ E.	126.7	0	0	0	8
.009	117	53.5	42.0	1.6	41.0	N. 73° 44′ E	41.0	0	0	0	9
.000	115	51.2	43.4	2.8	45 2	N. 79° 35′ E.	43.1	0	0	0	10
23.916	140	50.0	59.6	8.8	62.0	S. 79° 46′ E.	54.0	0	0	0	11
.871	133	78.1	40.0	9.9	30.6	N. 28° 31′ E.	43.3	0	0	0	12
24.129	326	214.0	79.6	7.7	89.9	N. 31° 27′ E.	157.6	0	0	T	13
.090	77	18.0	42.9	3.8	34.9	S. 51° 19′ E.	39.8	....	....	.04	14
23.941	101	53.6	27.1	10.2	38.2	N. 46° 35′ E.	38.5	0	0	0	15
24.122	289	145.7	77.9	72.9	90 9	N. 14° 52′ E.	70.1	0	0	0	16
.109	129	104.5	8.3	15.1	18.0	N. 1° 44′ E.	96.2	0	0	0	17
.149	126	73.6	34.4	1.2	40.1	N. 44° 47′ E.	55.2	0	0	0	18
23.785	281	201.4	12.6	153.2	8.4	N. 37° 29′ W.	238.0	0	0	0	19
24.065	173	78.3	52.3	42.5	49.6	N. 15° 16′ E.	26.9	0	0	0	20
23.853	284	51.9	190.3	113.3	18.3	S. 34° 28′ W.	167.9	0	0	0	21
.748	333	146.3	29.8	188.9	55.8	N. 48° 48′ W.	176.9	0	0	0	22
.882	191	107.3	40.3	50.1	53.4	N. 2° 49′ E.	67.1	9 a.m.	10 a.m.	.03	23
24.023	189	105.6	23.2	108.0	14.9	N 48° 29′ W.	124.3	0	0	0	24
23.849	321	196.5	6.9	214.3	7.3	N. 47° 31′ W.	280.7	0	0	0	25
24.226	221	142.4	47.3	2.5	84.8	N. 40° 52′ E.	125.8	0	0	0	26
.095	122	59.6	42.0	8.6	44.7	N. 64° 01′ E	40.1	0	0	0	27
23.677	111	28.1	68.9	30.5	17.1	S. 18° 11′ W.	42.9	0	0	0	28
672.629	5344	2800.3	1360.2	1287.2	1386.6	....	...	....	....	0.07	......
24.022	190.9	.....	......	.....	.....	....	......	....	....	....	......

MONTHLY SUMMARY OF

MARCH,

DATE.	THERMOMETERS.					PSYCHROMETER.						SUNSHINE RECORD'R			
	TEMPERATURES.			Hours of Extremes.		Relative Humidity.			Dew-point.			Clouds at Observ'n.	Number of Minutes.		
	Mean of 24 h.	Extremes. Max.	Min.	Max.	Min.	6 A.M.	12 M.	6 P.M.	6 A.M.	12 M.	6 P.M.		Actual.	Possible.	Per ct.
1	26.3	44	15	3 a.m.	8 p.m.	81	88	85	26	20	14	29	39	638	5
2	21.5	28	13	4 p.m.	12 n't	87	67	63	17	17	12	6	506	642	79
3	24.0	38	6	4 p.m.	7 a.m.	80	25	35	4	5	12	0	510	644	79
4	22.8	35	14	4 p.m.	8 a.m.	85	64	70	13	13	21	14	173	647	26
5	25.4	33	17	3 p.m.	8 a.m.	87	89	90	17	23	27	27	0	649	0
6	33.3	41	24	3 p.m.	12 n't	72	54	52	24	23	21	5	542	652	83
7	38.6	55	19	3 p.m.	3 a.m.	64	25	32	13	18	22	0	594	654	91
8	41.5	55	28	9 a.m.	12 n't	65	35	41	30	22	22	2	526	658	80
9	29.6	36	22	3 p.m.	6 a.m.	65	58	81	16	22	27	19	195	660	30
10	22.1	42	12	1 p.m.	12 n't	89	59	82	22	29	8	14	177	662	27
11	10.5	16	6	1 p.m.	12 n't	89	93	89	4	12	9	28	186	663	28
12	16.0	29	3	10 p.m.	4 a.m.	88	21	89	25	-9	26	14	290	666	43
13	25.8	59	15	3 p.m.	10 p.m.	94	86	10	20	36	15	10	328	669	49
14	16.5	25	10	4 p.m.	7 a.m.	90	85	64	8	14	13	20	296	671	44
15	11.0	13	8	1 p.m.	6 a.m.	94	91	92	8	12	8	30	25	677	4
16	3.7	10	-2	2 p.m.	11 p.m.	90	77	95	0	0	3	23	518	681	76
17	8.4	12	0	2 p.m.	1 a.m.	90	96	88	1	9	8	21	442	683	65
18	12.1	19	3	2 p.m.	12 n't	85	73	85	8	12	8	25	374	686	55
19	7.9	18	-5	3 p.m.	8 a.m.	93	76	66	5	8	5	3	566	687	82
20	22.5	36	4	5 p.m.	1 a.m.	59	61	63	2	20	22	3	541	689	78
21	34.5	45	23	5 a.m.	1 a.m.	68	50	67	27	24	26	12	394	691	57
22	37.1	53	22	4 p.m.	6 a.m.	64	46	51	13	28	30	9	475	694	68
23	44.7	58	30	2 p.m.	5 a.m.	59	28	44	23	25	29	5	550	695	79
24	43.3	57	30	5 p.m.	6 a.m.	81	53	43	27	33	31	18	289	695	41
25	46.8	60	35	1 p.m.	12 n't	71	18	45	31	16	30	16	358	698	51
26	41.9	53	32	2 p.m.	12 n't	57	41	86	32	29	36	19	356	700	51
27	32.1	34	30	5 p.m.	12 n't	91	100	100	30	32	32	30	58	703	8
28	35.3	44	30	3 p.m.	1 a.m.	91	77	76	30	32	31	24	248	705	35
29	39.7	49	30	3 p.m.	6 a.m.	72	40	48	24	25	26	5	574	709	81
30	41.9	53	30	4 p.m.	6 a.m.	81	37	38	27	25	25	3	566	715	79
31	46.3	64	32	4 p.m.	7 a.m.	58	31	41	22	27	33	11	321	718	45
Sums,	863.1	1214	536	....	....	2440	1847	2011	549	602	632	455	.....	.....	1619
Means,	27.8	39.2	17.3	....	....	79	60	65	18	19	20	15	.....	.....	....
Perctg.	.....	.....	.....	....	....	.....	.....	.....	.....	.....	.....	49%	...	.....	52%

INSTRUMENTAL RECORD.

1906.

BAROM.	ANEMOMETER AND ANEMOSCOPE.							RAIN GAUGE.			
	WIND.							Hours of Fall.			
Actual Pressure at 12 M.	Total Velocity.	Sum of Components. N.	S.	W.	E.	Equivalent. Direction.	Miles.	Earliest.	Latest.	Total Amount.	Date.
23.361	408	326.2	21.0	149.5	30.8	N. 21° 15′ W.	327.5	7 a.m.	7 p.m.	......	1
.841	......	......	......	......	......	....	......	0	0	0	2
.923	......	......	......	......	......	....	......	0	0	0	3
.933	154	5.7	98.7	1.1	109.8	S. 49° 27′ E.	143.1	0	0	0	4
24.010	187	138.1	28.1	4.1	43.9	N. 19° 54′ E.	116.9	....	12 m.	......	5
.276	238	219.0	0	33.1	44.7	N. 3° 02′ E.	219 3	0	0	0	6
.325	232	221.3	0	6.9	46.0	N. 10° 01′ E.	224.8	0	0	0	7
.242	229	180.3	25.9	7.0	59.9	N. 18° 55′ E.	163.2	0	0	0	8
.043	255	128.9	76.4	9.5	107.5	N. 61° 50′ E.	111.2	0	0	0	9
23.598	377	265.4	72.5	18.0	82.4	N. 18° 28′ E.	203.4	....	....	T	10
.909	265	1.0	193.8	0	177.3	S. 42° 36′ E.	262.0	1 a.m.	7 p.m.	.13	11
.756	149	0	98.6	0	102.8	S. 46° 12′ E.	142.5	0	0	0	12
.658	291	171.7	75.9	25.2	78.9	N. 29° 16′ E.	109.8	0	0	0	13
.880	249	0	177.6	0	158.9	S. 41° 10′ E.	235.9	....	1 p.m.	.11	14
.761	243	193.2	40.1	16.0	35.4	N. 7° 13′ E.	154.4	9 a.m.	12 n't	.80	15
24.000	147	15.9	85.6	0.4	95.1	S. 53° 39′ E.	117.6	0	0	0	16
23.940	97	38.9	28.5	4.6	52.7	N. 77° 48′ E.	49.2	....	....	.14	17
.875	310	302.4	0	12.3	36.2	N. 4° 31′ E.	303.5	....	....	.07	18
24.270	152	94.4	29.4	26.1	41.9	N. 13° 40′ E.	66.8	0	0	0	19
.122	149	119.6	8.1	22.8	26.0	N. 1° 39′ E.	111.5	0	0	0	20
.000	190	39.8	69.4	6.7	127.2	S. 76° 12′ E.	124.1	0	0	T	21
23 941	119	21.0	68.8	3.8	59.4	S. 49° 19′ E.	73.3	0	0	0	22
24.082	221	53.3	94.8	13.0	116.3	S. 68° 07′ E	111.4	0	0	0	23
.149	176	42.8	88.3	13.3	88.8	S. 58° 56′ E	88.1	0	0	0	24
23.832	206	121.3	29.9	68.4	25.6	N. 25° 06′ W.	101.0	0	0	T	25
24.005	173	95.5	46.7	51.5	34 3	N. 19° 25′ W.	51.7	5 p.m.	....	.30	26
.056	120	0.9	92.1	0.9	73.9	S. 38° 41′ E.	116.8	1 a m	....	1.17	27
.170	158	131.7	14.7	22.6	13.1	N. 4° 39′ W.	117.3	....	....	.02	28
.216	234	207.6	0	40.7	47.2	N. 1° 48′ E.	207.7	0	0	0	29
.157	161	49.1	80.0	8.1	75.7	S. 65° 26′ E.	74.3	0	0	0	30
23.862	156	41.6	74.6	39.8	47.9	S. 13° 47′ E.	34.0	....	....	T	31
43.193	6046	3226.6	1729.5	605.4	2038.6	....	......	....	....	2.74	.....
23.974	208.5†	......	......	......	......	....	......	....	....	...	.....
......	......	......	......	......	......	....	......	....	....	......	.....

† For 29 days.

MONTHLY SUMMARY OF

APRIL,

DATE.	THERMOMETERS. Temperatures. Mean of 24 h.	Extremes. Max.	Extremes. Min.	Hours of Extremes. Max.	Hours of Extremes. Min.	PSYCHROMETER. Relative Humidity. 6 A.M.	12 M.	6 P.M.	Dew-point. 6 A.M.	12 M.	6 P.M.	SUNSHINE RECORD. Clouds at Observ'n.	Number of Minutes. Actual.	Possible.	Pe ct
1	51.9	60	41	3 p.m.	1 a.m.	48	20	11	26	18	8	6	411	721	5
2	44.6	54	33	4 p.m.	12 n't	25	11	17	10	2	11	2	556	724	7
3	27.2	33	24	1 a.m.	11 a.m.	79	67	79	22	17	22	28	58	728	
4	32.0	42	23	5 p.m.	5 a.m.	88	56	56	20	25	25	18	185	730	2
5	45.3	57	30	3 p.m.	5 a.m.	72	32	36	25	24	26	1	590	733	8
6	49.6	65	30	3 p.m.	4 a.m.	59	22	42	23	24	35	4	582	735	7
7	41.0	48	32	11 a.m.	7 a.m.	92	73	86	33	35	36	29	333	739	4
8	47.0	56	38	6 p.m.	12 n't	69	63	47	38	36	34	12	541	741	7
9	53.1	69	34	4 p.m.	4 a.m.	51	24	17	25	26	19	5	634	744	8
10	51.0	62	39	4 p.m.	4 a.m.	49	.....	34	22	....	30	.....	548	748	7
11	52.7	68	38	3 p.m.	7 a.m.	64	11	19	29	11	18	14	477	752	6
12	38.3	48	32	1 a.m.	8 p.m.	85	56	62	34	25	26	27	52	754	
13	37.0	50	29	5 p.m.	6 a.m.	80	36	18	25	17	26	4	566	756	7
14	39.5	52	24	3 p.m.	4 a.m.	59	24	24	17	16	16	14	.....	759	...
15	46.7	61	30	3 p.m.	5 a.m.	63	20	37	22	20	31	11	579	762	7
16	44.5	56	36	1 p.m.	5 a.m.	69	51	14	28	36	6	20	.....	765	..
17	52.3	69	34	2 p.m.	5 a.m.	53	27	51	28	31	41	20	490	767	6
18	45.0	55	38	12 m.	12 n't	68	45	93	34	35	38	27	.....	769	..
19	40.5	49	34	6 p.m.	12 n't	84	50	37	33	29	25	20	.....	771	...
20	47.3	64	31	4 p.m.	3 a.m.	66	23	24	25	22	24	0	.....	773	..
21	53.9	67	38	3 p.m.	4 a.m.	53	33	33	28	35	33	9	648	776	8
22	58.1	77	39	5 p.m.	5 a.m.	50	22	16	24	31	25	5	574	778	7
23	....	74	45	......	....	61	14	17	32	21	24	18	673	782	8
24	....	....	...	......	......	41	9	27	33	5	23	16	444	785	5
25	52.2	65	40	4 p.m.	6 a.m.	48	22	36	26	20	33	19	.....	788	...
26	38.0	45	32	1 a.m.	3 p.m.	78	86	74	36	36	27	25	0	791	
27	38.1	46	32	5 p.m.	3 a.m.	74	54	48	27	26	26	12	.....	794	...
28	43.6	53	30	3 p.m.	5 a.m.	51	31	32	30	23	15	14	.....	797	...
29	48.5	60	40	5 p.m.	2 a.m.	72	51	63	34	34	44	17	511	799	6
30	47.3	55	40	......	6 a.m	66	32	36	32	26	26	8	652	800	8
Sums,	1266.2	1660	986	......	....	1917	1065	1186	821	706	773	405	.....	.....	13
Means,	45.2*	57.2†	34.0†	......	....	64	37†	40	27	24†	26	14	.....	.....	...
Peretg.	......	......	......	......	....	...	...	...	...	....	...	45	...	.....	61

* For 28 days. † For 29 days. ‡ For 22 days.

INSTRUMENTAL RECORD.

1906.

ROM.	ANEMOMETER AND ANEMOSCOPE.							RAIN GAUGE.			
	WIND.										
ctual essure 12 M.	Total Velocity.	Sum of Components.				Equivalent.		Hours of Fall.		Total Amount.	Date.
		N.	S.	W.	E.	Direction.	Miles.	Earliest.	Latest.		
3.641	350	16.2	296.8	55.5	58.8	S. 0° 40′ E.	280.6	0	0	0	1
.862	443	88.8	248.3	240.8	2.6	S. 54° 58′ W.	277.8	0	0	0	2
4.243	292	254.4	3.9	0	63.7	N. 14° 16′ E.	258.5	....	....	T	3
.154	153	32.4	77.7	26.5	74.8	S. 46° 50′ E.	66.2	....	....	.03	4
.221	222	62.3	118.6	11.7	102.7	S. 58° 15′ E.	107.0	0	0	0	5
.144	213	54.1	112 7	12.8	106.4	S. 57° 57′ E.	110.4	0	0	0	6
3.588	406	320.0	30.3	103.1	54.3	N. 9° 34′ W.	293.8	....	8 p.m.	.62	7
4.138	318	255.3	13.8	91.4	50.4	N. 9° 38′ W.	245.0	....	....	.01	8
.048	156	37.4	77.5	58.1	26.4	S. 38° 20′ W.	51.1	0	0	0	9
......	185	85.5	62.8	16.5	68.8	N. 66° 32′ E.	57.0	....	....	......	10
3.789	226	39.2	126.3	82.5	45.3	S. 23° 08′ W.	94.7	0	0	0	11
.836	526	469.7	0	213.1	2.4	N. 24° 10′ W.	514.8	....	....	.14	12
4.103	277	257.7	0	27.5	44.6	N. 3° 48′ E.	258.3	0	0	0	13
.127	149	41.7	67.7	5.5	80.4	S. 70° 51′ E.	79.3	0	0	0	14
.099	168	59.5	80.6	8.9	63.0	S. 68° 42′ E.	58.1	0	0	0	15
.139	148	43.3	76.0	11.8	51.2	S. 50° 19′ E.	51.2	1 p.m.	2 p.m.	.05	16
.042	136	76.4	35.0	35.0	21.9	N. 17° 34′ W.	43.4	0	0	0	17
.097	309	284.5	0	95.4	3.4	N. 17° 55′ W.	299.0	....	7 p.m.	.58	18
.325	275	226.9	9.2	81.6	42.6	N. 10° 10′ W.	221.2	....	....	.02	19
.216	194	180.2	0	6.6	45.1	N. 12° 04′ E.	184.3	0	0	0	20
.111	172	62.1	82.6	0.5	64.9	S. 72° 20′ E.	67.6	0	0	0	21
.076	160	82.3	43.4	51.8	14.7	N. 43° 39′ W.	53.8	0	0	0	22
3.930	238	50.6	146.3	87.6	25.5	S. 32° 59′ W.	114.1	0	0	0	23
.609	401	213.6	97.5	176.2	38.1	N. 49° 57′ W.	180.4	2 p.m.	3 p.m	.05	24
.814	199	97.8	45.1	57.7	50.6	N. 7° 40′ W.	53.2	0	0	0	25
.864	313	280.1	0	101.2	8.4	N. 18° 20′ E.	295.1	....	....	.30	26
.989	421	379.8	0	124.8	22 3	N. 15° 06′ W.	393.4	....	....	.04	27
.951	204	62.1	102.0	17.6	78.8	S. 56° 53′ E.	73.0	7 p m.	....	.26	28
.901	195	9.6	127.0	31.9	95.5	S. 28° 27′ E.	133.5	....	....	.10	29
.889	279	137.3	39.7	144.6	11.3	N. 53° 47′ W.	165.2	....	....	......	30
5.946	7728	4240.8	2120.8	1978.2	1408.9	....	....	....	....	2.20	......
3.998†	257.6	......	......	......	......	....	....	....	....	......	......

MONTHLY SUMMARY OF

MAY,

Date.	Thermometers. Temperatures. Mean of 24 h.	Extremes. Max.	Extremes. Min.	Hours of Extremes. Max.	Hours of Extremes. Min.	Psychrometer. Relative Humidity. 6 A.M.	12 M.	6 P.M.	Dew-point. 6 A.M.	12 M.	6 P.M.	Clouds at Observ'ns.	Sunshine Record. Number of Minutes. Actual.	Possible.
1	48.5	60	32	3 p.m.	5 a.m.	61	26	31	25	22	27	10	523	802
2	44.8	54	37	1 p.m.	6 a.m.	49	43	68	22	31	36	11	388	804
3	56.2	70	39	5 p.m.	4 a.m.	33	26	29	23	29	32	8	*482	807
4	59.4	72	41	4 p.m.	12 n't	29	21	21	23	27	27	6	326	808
5	36.0	41	32	1 a.m.	12 n't	75	85	75	29	24	28	30	43	810
6	36.0	42	32	6 p.m.	4 a.m.	81	77	66	27	32	31	23	0	813
7	50.1	65	32	4 p.m.	3 a.m.	49	31	44	22	32	38	6	680	816
8	45.5	52	36	5 p.m.	5 a.m.	69	36	38	28	33	29	12	482	819
9	52.9	68	35	2 p.m.	5 a.m.	61	31	51	25	35	41	10	554	822
10	55.4	67	44	1 p.m.	5 a.m.	52	25	41	31	30	37	13	636	826
11	57.0	70	41	1 p.m.	5 a.m.	55	30	36	30	36	40	16	180	827
12	58.9	72	50	12 m.	12 n't	34	21	47	28	36	43	8	537	829
13	54.0	65	41	6 p.m.	6 a.m.	38	37	37	22	31	31	14	183	832
14	56.4	67	47	4 p.m.	6 a.m.	44	37	41	29	36	38	12	*620	833
15	61.4	76	41	5 p.m.	5 a.m.	68	21	12	34	30	20	2	*570	834
16	66.1	79	48	5 p.m.	6 a.m.	56	12	13	38	19	22	20	600	835
17	58.4	67	48	1 a.m.	7 a.m.	47	30	35	29	30	31	12	589	836
18	58.9	75	39	5 p.m.	5 a.m.	21	19	33	12	28	38	4	524	837
19	57.3	66	48	2 p.m.	12 n't	44	53	58	34	19	18	15	255	839
20	55.0	69	43	12 m.	4 a.m.	40	17	69	27	48	18	12	215	839
21	60.2	75	42	3 p.m.	4 a.m.	49	27	27	32	37	33	3	421	841
22	56.8	71	47	1 p.m.	5 a.m.	43	33	55	36	38	42	10	387	843
23	50.8	57	45	6 p.m.	12 n't	76	76	70	73	44	41	25	24	845
24	46.3	55	42	1 p.m.	11 p.m.	74	44	70	37	34	39	26	196	846
25	53.2	68	41	4 p.m.	5 a.m.	66	54	52	32	45	37	16	310	846
26	55.7	67	46	5 p.m.	6 a.m.	64	53	64	37	44	52	11	555	849
27	51.4	63	44	4 p.m.	6 a.m.	87	77	60	41	45	44	27	241	851
28	59.8	76	48	5 p.m.	6 a.m.	59	16	31	36	42	41	13	507	853
29	57.5	64	48	3 a.m.	12 n't	52	30	22	42	28	24	3	636	854
30	56.0	72	37	4 p.m.	5 a.m.	53	23	22	29	28	26	5	637	855
31	55.9	67	42	4 p.m.	6 a.m.	50	37	25	29	36	28	6	541	856
Sums,	1671.8	2032	1288	......	......	1679	1208	1343	962	1059	1095	389	.....	.....
Means,	53.9	65.5	41.5	......	......	54	39	43	31	34	35	13	.....	.....
Perctg.	....	....	....	....	....	....	....	....	....	....	....	42%	.....	.....

18 * In whole or part from Knob Hill record - for 3.

INSTRUMENTAL RECORD.

1906.

arom.	Anemometer and Anemoscope.								Rain Gauge.			
	Wind.											
ctual essure ; 12 m.	Total Velocity.	Sum of Components. N.	S.	W.	E.	Equivalent. Direction.	Miles.	Hours of Fall. Earliest.	Latest.	Total Amount.	Date.
23.916	188	50.1	66.7	69.5	61.8	S. 24° 53′ W.	18.3	0	0	0	1
24.025	209	81.4	85.8	12.8	89.5	S. 86° 43′ E.	76.8	4 p.m.	5 p.m.	.11	2
23.904	177	61.3	44.0	87.9	45.4	N. 67° 51′ W.	45.9	0	0	0	3
.847	398	259.5	9.2	238.0	14.6	N. 41° 45′ W.	335.6	0	0	0	4
24.065	184	74.2	61.8	3.4	96.3	N. 82° 24′ E.	93.7	11 a.m.	....	.15	5
.035	148	10.0	101.3	5.9	86.4	S. 41° 24′ E.	121.7	....	....	.05	6
.039	155	83.4	42.2	8.7	58.2	N. 50° 13′ E.	64.4	0	0	0	7
.349	185	11.3	114.9	6.3	124.1	S. 48° 40′ E.	156.9	0	0	0	8
.287	161	45.6	70.9	8.8	70.6	S. 67° 44′ E.	66.8	4 p.m.	4 p.m.	.01	9
.169	171	74.7	52.1	36.7	48.8	N. 28° 10′ E.	25.6	0	0	0	10
23.998	158	104.1	27.4	19.5	42.3	N. 16° 34′ E.	80.0	0	0	0	11
.806	267	36.7	153.8	119.8	50.9	S. 30° 27′ W.	136.0	1 p.m.	1 p.m.	.02	12
.859	225	29.2	115.3	99.4	51.1	S. 29° 17′ W.	98.7	0	0	0	13
.993	239	15.8	146.2	36.4	133.5	S. 36° 40′ E.	162.6	0	0	0	14
.836	250	31.5	186.8	25.1	75.3	S. 17° 55′ E.	163.2	0	0	0	15
.897	179	28.0	109.3	18.6	72.6	S. 33° 35′ E.	97.6	0	0	0	16
24.101	324	49.8	197.9	5.3	184.8	S. 50° 28′ E.	232.7	0	0	0	17
.168	139	41.5	54.1	3.8	69.3	S. 79° 07′ E.	66.7	0	0	0	18
.134	198	34.7	96.4	24.1	112.9	S. 55° 12′ E.	108.2	12 m.	4 p.m.	.47	19
23.914	156	75.6	26.8	74.5	19.0	N. 48° 41′ W.	73.9	1 p.m.	4 p.m.	.08	20
.843	164	91.5	17.4	57.5	41.4	N. 12° 16′ W.	75.8	0	0	0	21
.895	236	178.8	30.0	36.8	41.4	N. 1° 46′ E.	148.9	5 p.m.	5 p.m.	T	22
.879	169	108.9	6.4	62.7	28.0	N. 18° 42′ W.	108.2	3 a.m.	12 n't	1.23	23
.670	181	50.2	64.5	48.5	78.1	S. 64° 13′ E.	32.9	2 p.m.	11 p.m.	.30	24
.707	193	140.6	22.3	42.5	34.5	N. 3° 52′ W.	118.6	0	0	0	25
.827	178	15.1	112.0	7.1	110.8	S. 46° 57′ E.	142.0	0	0	0	26
.970	199	0	136.6	0	141.3	S. 45° 58′ E.	196.5	....	....	T	27
.936	269	0	231.2	1.6	104.2	S. 23° 56′ E.	253.0	8 a.m.	8 a.m.	T	28
.778	292	22.7	135.9	209.8	11.0	S. 60° 21′ W.	228.7	0	0	0	29
.953	143	39.3	51.2	37.6	54.7	S. 55° 10′ E.	20.8	0	0	0	30
24.057	198	86.7	66.8	24.9	80.9	N. 70° 26′ E.	59.4	12 n't	12 n't	.03	31
3.057	6333	1932.2	2637.2	1433.5	2233.7	....	.....	....	....	2.45	......
23.970	204.	......	......	......	......	....	.....	....	....	......	......
......	......	......	......	......	......	....	.....	....	....	......	......

MONTHLY SUMMARY OF

JUNE,

Date.	Thermometers.					Psychrometer.						Sunshine Record			
	Temperatures.			Hours of Extremes.		Relative Humidity.			Dew-point.			Clouds at Observ'n.	Number of Minutes.		P
	Mean of 24 h.	Extremes. Max.	Extremes. Min.	Max.	Min.	6 A.M.	12 M.	6 P.M.	6 A.M.	12 M.	6 P.M.		Actual.	Possible	
1	50.2	58	43	5 p.m.	6 a.m.	86	76	64	40	44	46	19	297	856	
2	51.9	66	46	1 p.m.	6 a.m.	63	67	83	36	51	49	21	125	857	
3	52.1	64	45	11 a.m.	5 a.m.	64	39	47	37	39	39	21	350	858	
4	59.1	74	42	5 p.m.	5 a.m.	49	24	33	28	32	41	12	667	859	
5	67.7	80	48	2 p.m.	4 a.m.	44	18	23	38	29	36	7	625	859	
6	65.2	73	53	3 p.m.	12 n't	24	14	12	24	17	17	0	815	860	
7	58.1	75	43	3 p.m.	5 a.m.	29	16	42	18	22	43	0	825	861	
8	59.0	78	38	5 p.m.	4 a.m.	44	23	21	34	28	35	0	274	862	
9	66.8	81	47	4 p.m.	2 a.m.	47	13	29	39	26	43	5	740	862	
10	65.8	78	53	5 p.m.	5 a.m.	47	44	39	39	18	49	14	520	862	
11	63.7	77	55	3 p.m.	5 a.m.	49	52	50	37	53	53	14	425	862	
12	62.0	72	56	1 p.m.	6 a.m.	68	69	73	46	56	59	28	187	863	
13	62.2	74	52	4 p.m.	5 a.m.	78	74	50	47	62	53	16	415	863	
14	64.3	74	53	1 p.m.	5 a.m.	84	54	53	73	57	58	12	660	863	
15	67.8	83	56	5 p.m.	5 a.m.	75	47	38	51	54	54	5	672	863	
16	71.7	91	52	3 p.m.	5 a.m.	..	27	25	.....	48	44	8	656	863	
17	56.2	66	46	1 p.m.	12 n't	35	41	76	36	42	43	28	85	863	
18	57.8	69	41	5 p.m.	5 a.m.	60	33	30	38	35	36	0	805	864	
19	60.2	76	44	2 p.m.	5 a.m.	51	21	36	34	32	43	4	594	864	
20	54.3	64	48	5 p.m.	5 a.m.	52	31	41	31	30	38	3	665	865	
21	62.9	81	39	4 p.m.	5 a.m.	61	27	31	32	40	44	3	596	865	
22	66.2	82	50	12 m.	12 n't	43	20	20	36	35	28	15	408	865	
23	48.3	51	44	2 p.m.	11 p.m.	88	88	94	48	45	46	29	0	865	
24	52.5	65	45	2 p.m.	4 a.m.	88	60	..	45	45	.....	23	292	864	
25	59.5	70	46	5 p.m.	4 a.m.	.....		.	..	.....	....	11	593	864	
26	65.2	82	47	4 p.m.	6 a.m.	.....	.. .		....	....	.....	14	565	863	
27	68.7	84	51	3 p.m.	6 a.m.	......	.....	.....	.....	.....	....	13	340	863	
28	67.0	81	54	5 p.m.	6 a.m.	.....	....	.....	....	.....	.....	6	764	863	
29	66.1	76	51	5 p.m.	5 a.m.	.. ..	..	..	.. .	. .	.. ..	3	800	863	
30	68.2	85	51	5 p.m.	4 a.m.	.....	.....	.....	.....	..	....	9	714	863	
Sums,	1840.7	2230	1439	......	......	.	..	.	. .	. .	...	343	.....	.....	1
Means,	61.4	74.3	48.0	....	....	.....	..	..	.....	.....	....	11	.....	.....	..
Perctg.	......	.....	.....	....	....	.....	.....	.....	.....	.....	.....	38%	.....	.....	

INSTRUMENTAL RECORD.

1906.

BAROM.	ANEMOMETER AND ANEMOSCOPE.							RAIN GAUGE.			DATE.
	WIND.							Hours of Fall.		Total Amount.	
Actual Pressure at 12 M.	Total Velocity.	Sum of Components. N.	S.	W.	E.	Equivalent. Direction.	Miles.	Earliest.	Latest.		
24.171	258	5.1	190.5	0	163.8	S. 41° 28′ E	247.4	1 a.m.	6 a.m.	.09	1
.022	146	44.7	66.3	39.2	44.2	S. 13° 02′ E.	22.1	4 p.m.	4 p.m	.06	2
23.897	158	87.7	17.6	72.1	13.8	N. 39° 45′ W.	91.1	0	0	0	3
.945	151	34.6	84.3	11.2	70.3	S. 49° 57′ E.	77.2	0	0	0	4
.878	273	38.6	198.6	79.9	36.6	S. 15° 09′ E.	165.7	0	0	0	5
.737	424	3.4	120.8	385.4	6.7	S. 72° 47′ W.	396.6	0	0	0	6
.804	220	71.8	39.8	127.8	47.5	N. 68° 16′ W.	86.4	0	0	0	7
24.001	133	46.3	48.1	10.9	66.2	S. 88° 08′ E.	55.3	0	0	0	8
.145	......	......	......	......	......	....	......	0	0	0	9
.172	152	9.0	96.8	2.9	101.5	S. 48° 19′ E.	132.0	0	0	0	10
.196	154	0.8	108.9	7.9	88.2	S. 36° 36′ E.	134.7	8 p.m.	10 p.m.	.18	11
.084	117	2.7	69.2	21.0	65.3	S. 33° 40′ E.	79.9	0	0	0	12
.040	......	......	......	......	......	....	......	0	0	0	13
23.978	......	......	....	....	......	....	......	0	0	0	14
24.014	......	......	......	......	......	....	......	......	......	.04	15
23.893	134	31.9	79.2	5.4	57.3	S. 47° 39′ E.	70.2	0	0	0	16
.910	155	142.3	0	20.5	29.5	N. 3° 37′ E.	142.7	3 p.m	5 p.m.	.12	17
24.107	83	37.1	27.4	6.6	39.3	N. 73° 27′ E.	34.1	0	0	0	18
23.928	137	104.6	12.0	3.2	43.2	N. 23° 22′ E.	100.9	0	0	0	19
24.171	86	31.1	36.8	0	42.7	S. 82° 24′ E.	43.0	0	0	0	20
23.968	74	34.1	19.5	2.4	33.3	N. 64° 43′ E.	34.1	0	0	0	21
.874	99	85.2	3.9	8.0	17.1	N. 6° 23′ E.	81.8	....	....	T	22
.980	......	......	......	......	......	....	......	8 a.m.	1 p.m.	.41	23
24.023	......	......	......	......	......	....	......	....	....	.15	24
.116	61	1.7	36.9	1.0	42.9	S. 49° 58′ E.	54.7	....	....	T	25
23.807	88	33.4	46.1	15.6	11.4	S. 18° 18′ W.	13.3	....	....	T	26
.877	76	18.8	49.1	18.2	6.1	S. 21° 46′ W.	32.6	0	0	0	27
.849	75	10.0	47.7	30.5	11.9	S. 26° 16′ W.	42.0	0	0	0	28
.951	255	26.5	188.8	7.8	109.9	S. 32° 11′ E.	191.8	0	0	0	29
24.096	142	107.5	1.4	30.0	41.7	N. 6° 18′ E.	106.6	0	0	0	30
719.634	3651*	1008.9	1589.7	907.5	1190.4	....	......	....	....	1.05	......
23.988	......	......	......	......	......	....	......	....	....	......	......
......	......	......	......	......	......	....	......	....	....	......	......

* For 24 days.

MONTHLY SUMMARY OF

JULY,

DATE.	THERMOMETERS. Temperatures. Mean of 24 h.	Extremes. Max.	Extremes. Min.	Hours of Extremes. Max.	Hours of Extremes. Min.	PSYCHROMETER. Relative Humidity. 6 A.M.	Relative Humidity. 12 M.	Relative Humidity. 6 P.M.	Dew-point. 6 A.M.	Dew-point. 12 M.	Dew-point. 6 P.M.	SUNSHINE RECORD'R. Clouds at Observ'n.	Number of Minutes. Actual.	Number of Minutes. Possible.	Per ct.
1	67.2	83	51	1 p.m.	5 a.m.	...	...	...	...	...	...	15	557	863	63
2	52.1	74	51	...	...	...	...	...	...	...	...	30	0	862	0
3	53.7	75	46	5 p.m.	5 a.m.	...	...	...	...	...	...	27	25	862	3
4	56.7	70	42	5 p.m.	5 a.m.	...	...	...	...	...	...	12	685	860	80
5	59.4	70	43	5 p.m.	5 a.m.	...	...	...	...	...	...	11	624	860	73
6	59.7	70	51	4 p.m.	6 a.m.	...	...	36	...	...	40	17	483	860	56
7	66.2	64	51	2 p.m.	6 a.m.	76	66	62	41	49	48	27	70	860	8
8	55.0	69	50	12 m.	5 a.m.	71	70	94	43	50	53	23	62	859	7
9	59.2	72	51	...	6 a.m.	82	83	64	45	58	52	26	195	859	23
10	60.2	76	50	4 a.m.	1 p.m.	77	59	75	45	57	53	22	416	857	49
11	64.8	80	51	4 p.m.	3 a.m.	65	50	51	56	54	52	15	594	857	69
12	66.1	76	56	3 p.m.	5 a.m.	62	56	46	49	55	51	23	336	856	39
13	62.7	76	52	12 m.	5 a.m.	60	54	81	44	57	59	17	380	856	44
14	61.0	72	56	11 a.m.	12 n't	70	77	85	49	57	55	21	332	854	39
15	57.0	66	54	2 p.m.	4 a.m.	78	71	84	48	52	54	15	331	852	39
16	61.5	77	50	...	4 a.m.	77	68	60	46	54	54	10	513	850	60
17	64.5	80	50	2 p.m.	5 a.m.	77	37	45	45	50	54	5	612	849	72
18	64.0	80	54	11 a.m.	5 a.m.	66	39	79	48	50	58	22	350	847	41
19	66.8	80	54	5 p.m.	4 a.m.	78	34	34	47	46	46	2	748	846	88
20	70.5	88	53	3 p.m.	5 a.m.	71	20	26	52	38	45	4	755	844	89
21	68.8	88	53	1 p.m.	5 a.m.	36	27	50	40	48	54	14	350	843	42
22	70.2	83	60	3 p.m.	6 a.m.	41	35	42	43	49	54	19	500	841	59
23	64.4	84	55	...	6 a.m.	69	44	61	47	52	54	22	209	839	25
24	61.9	78	54	11 a.m.	5 a.m.	80	66	70	55	59	59	21	466	837	56
25	66.9	85	52	5 p.m.	5 a.m.	74	26	38	49	43	51	12	695	836	83
26	67.1	83	55	2 p.m.	5 a.m.	66	42	42	48	51	52	20	382	836	46
27	64.2	74	56	11 a.m.	12 n't	63	44	77	50	50	57	20	196	835	23
28	62.3	74	55	5 p.m.	5 a.m.	71	47	48	51	48	50	14	485	833	58
29	62.3	77	48	6 p.m.	6 a.m.	72	41	38	44	50	47	12	552	831	66
30	64.7	81	53	...	6 a.m.	58	30	60	42	46	50	6	386	829	47
31	68.9	86	52	1 p.m.	4 a.m.	48	24	37	36	44	46	10	388	827	47
Sums,	1950.0	2391	1612	...	...	1688	1210	1485	1166	1267	1348	514	...	...	149
Means,	62.9	77.1	52.0	...	...	68*	48*	57†	47*	51*	52†	17	...	...	...
Perctg.	...	...	...	...	...	...	...	...	...	...	...	55%	...	...	48%

* For 25 days. † For 26 days.

INSTRUMENTAL RECORD.

1906.

BAROM.	ANEMOMETER AND ANEMOSCOPE.							RAIN GAUGE.			
	WIND.							Hours of Fall.			
Actual Pressure at 12 M.	Total Velocity.	Sum of Components.				Equivalent.				Total Amount.	Date.
		N.	S.	W.	E.	Direction.	Miles.	Earliest.	Latest.		
24.143										T	1
.363								3 a.m.	6 p.m.	.18	2
.361								0	0	0	3
.334								0	0	0	4
.307								0	0	0	5
.276								10 p.m.	12 n't	.14	6
.226										T	7
.199								1 p.m.	3 p.m.	.57	8
.161								4 p.m.	6 p.m.	.07	9
.171								2 p.m.	2 p.m.	.01	10
.169								0	0	0	11
.246								0	0	0	12
.148								6 p.m.	6 p.m.	.03	13
.068								5 p.m.	6 p.m.	.04	14
.184										0	15
.143								12 m.	3 p.m.	.18	16
.124										T	17
.064								3 p.m.	4 p.m.	.82	18
.172								0	0	0	19
.158								0	0	0	20
.143										T	21
.276								7 p.m.	7 p.m.	.07	22
.194								12 m.	9 p.m.	.14	23
.189								3 a.m.	2 p.m.	.11	24
.130								0	0	0	25
.090								0	0	0	26
.099								2 p.m.	3 p.m.	.03	27
.268								0	0	0	28
.199								0	0	0	29
.117										T	30
.095								0	0	0	31
749.817										2.39	
24.188											

MONTHLY SUMMARY OF

AUGUST,

DATE.	THERMOMETERS.					PSYCHROMETER.						SUNSHINE RECORD'R			
	TEMPERATURES.			Hours of Extremes.		Relative Humidity.			Dew-point.			Clouds at Observ'n.	Number of Minutes.		
	Mean of 24 h.	Extremes. Max.	Min.	Max.	Min.	6 A.M.	12 M.	6 P.M.	6 A.M.	12 M.	6 P.M.		Actual.	Possible.	Per ct.
1	66.9	84	54	2 p.m.	4 a.m.	56	29	57	43	47	51	23	273	824	33
2	66.5	83	48	3 p.m.	5 a.m.	66	28	33	44	41	44	5	654	821	80
3	63.5	81	52	2 p.m.	3 a.m.	50	32	80	38	45	55	16	0	818	0
4	64.6	78	50	2 p.m.	4 a.m.	61	41	43	40	50	50	11	637	816	78
5	61.1	76	51	2 p.m.	5 a.m	67	50	63	43	53	51	14	420	814	52
6	64.7	80	50	1 p.m.	5 a.m.	51	40	45	40	52	50	12	519	812	64
7	61.2	73	51	12 m.	6 a.m.	67	51	80	43	51	56	16	388	809	48
8	65.2	81	50	3 p.m.	5 a.m.	62	27	29	41	40	41	1	757	807	94
9	67.2	85	50	3 p.m.	5 a.m.	68	33	62	46	48	65	....	585	805	73
10	67.5	79	58	2 p.m.	5 a.m.	53	35	57	44	45	52	8	442	803	55
11	65.4	77	52	4 p.m.	4 a.m.	74	50	49	49	53	52	3	725	800	91
12	66.1	78	48	5 p.m.	5 a.m.	51	42	....	36	51	....	1	738	798	92
13	68.8	85	51	3 p.m.	5 a.m.	75	25	37	51	44	50	6	601	796	76
14	67.7	84	60	1 p.m.	6 a.m.		30	57	..	18	51	18	374	794	47
15	67.5	83	55	12 m.	5 a.m.	84	35	50	52	49	53	8	519	792	66
16	70.0	85	55	4 p.m.	6 a.m.	74	36	36	50	52	50	6	705	790	89
17	70.7	85	55	3 p.m.	6 a.m.	66	67	35	52	65	49	....	614	787	78
18	69.2	84	52	4 p.m.	6 a.m.	59	30	31	49	46	47	....	763	784	97
19	70.6	86	52	4 p.m.	5 a.m.	60	27	28	44	46	45	4	673	780	86
20	70.3	85	60	3 p.m.	4 a.m.	..	32	50	....	49	54	11	447	777	58
21	70.2	86	55	3 p.m.	6 a.m	72	34	45	55	53	54	13	602	773	78
22	66.7	81	56	1 p.m.	4 a.m.	73	40	58	70	52	55	21	282	772	37
23	60.5	69	52	2 p.m.	8 a.m.	87	54	81	54	50	57	23	111	770	14
24	62.8	74	53	3 p.m.	6 a.m.	55	62	58	47	56	55	6	480	769	62
25	59.1	70	51	11 a.m.	4 a.m.	55	38	55	42	41	47	11	337	767	44
26	57.0	67	51	4 p.m.	4 a.m.	54	51	54	34	45	46	10	555	764	73
27	61.0	76	45	3 p.m.	6 a.m.	73	43	39	44	49	45	4	680	760	89
28	67.0	82	54	2 p.m.	1 a.m.	63	24	29	44	38	41	7	700	758	92
29	68.5	*82	52	4 p.m.	6 a.m.	46	25	....	37	39	....	....	579	755	77
30	58.9	*73	45	9 a.m.	1 p.m.	60	73	66	44	47	49	17	332	752	44
31	63.3	80	51	4 p.m.	5 a.m.	94	37	41	50	46	45	5	655	750	87
Sums,	2029.7	2472	1619	....	....	1876	1221	1448	1326	1491	1460	280	.....	.....	2054
Means,	65.5	79.7	52.2	....	....	†65	39	†50	†46	18	†50	10	.....	.....	....
Perctg.	.....			....	....							‡35%	.....	.....	66%

* Record doubtful. † For 29 days. ‡ For 27 days.

INSTRUMENTAL RECORD.

1906.

BAROM.	ANEMOMETER AND ANEMOSCOPE.							RAIN GAUGE.			
	WIND.										
Actual Pressure at 12 M.	Total Velocity.	Sum of Components.				Equivalent.		Hours of Fall.		Total Amount.	Date.
		N.	S.	W.	E.	Direction.	Miles.	Earliest.	Latest.		
24.067	98	63.3	18.0	30.9	11.6	N. 23° 05′ W.	49.2	....	....	.01	1
.244	75	41.1	15.3	3.1	36.4	N. 52° 14′ E.	42.1	0	0	0	2
.197	141	109.4	13.4	26.4	18.9	N. 4° 28′ W.	96.3	5 p.m.	6 p.m.	.01	3
.167	65	35.1	24.0	8.5	11.8	N. 23° 45′ E.	8.1	0	0	T	4
.113	75	31.5	28.5	16.6	17.4	N. 14° 56′ E.	3.1	2 p.m.	6 p.m.	.13	5
.099	70	45.2	16.0	5.9	15.1	N. 17° 29′ E.	30.6	2 p.m.	2 p.m.	.02	6
.224	81	52.1	10.4	26.9	10.3	N. 21° 42′ W.	44.8	2 p.m.	6 p.m.	.33	7
.140	63	36.1	8.9	9.9	22.9	N. 25° 33′ E.	30.1	0	0	0	8
.153	92	37.8	28.2	22.5	16.8	N. 30° 42′ W.	11.1	7 p.m.	10 p.m	.10	9
.259	86	68.2	0	32.7	6.7	N. 20° 52′ W.	72.9	0	0	0	10
.269	74	26.8	34.3	5.8	28.9	S. 72° 01′ E.	24.2	0	0	0	11
.210	64	18.7	31.8	6.6	32.4	S. 63° 05′ E.	28.9	0	0	0	12
.073	75	50.2	17.9	7.0	13.4	N. 12° 54′ E.	33.1	0	0	0	13
.041	75	44.9	14.3	29.1	8.2	N. 34° 20′ W.	37.0	2 p.m.	2 p.m.	.04	14
.066	71	40.8	16.1	9.6	17.8	N. 18° 22′ E.	26.0	....	....	.06	15
.061	70	39.8	22.0	0.6	18.2	N. 44° 41′ E.	25.0	0	0	0	16
.109	65	34.8	20.9	1.5	20.3	N. 53° 31′ E.	23.3	0	0	0	17
.101	57	33.0	17.4	4.7	13.1	N. 28° 18′ E.	17.7	0	0	0	18
.017	60	33.4	15.9	0.8	21.7	N. 50° 04′ E.	27.2	0	0	0	19
.032	77	47.9	13.2	19.5	15.2	N. 7° 04′ W.	34.9	7 p.m.	10 p.m.	.03	20
.020	73	45.4	15.0	10.6	17.9	N. 13° 30′ E.	31.2	5 p.m.	6 p.m.	T	21
.020	84	79.7	0	10.4	7.7	N. 1° 56′ W.	80.0	2 p.m	10 p.m.	.06	22
.140	84	69.5	0	27.0	7.7	N. 15° 31′ W.	72.1	1 a.m.	12 n't	.30	23
.095	51	7.4	30.6	1.4	27.4	S. 48° 16′ E.	34.8	2 a.m.	2 a.m.	.01	24
.152	81	70.3	0.9	20.8	6.8	N. 11° 24′ W.	70.8	2 p.m.	4 p.m.	.03	25
.329	64	17.4	31.8	9.8	28.5	S. 52° 24′ E.	23.6	1 a.m.	1 a.m	.01	26
.123	62	41.9	14.1	0.9	14.1	N. 25° 24′ E.	30.7	0	0	0	27
.046	52	33.9	12.6	4.0	11.6	N. 19° 38′ E.	22.6	0	0	0	28
.113	48	27.2	6.0	5.1	18.6	N. 32° 29′ E.	25.1	0	0	0	29
.275	60	26.6	21.8	12.0	16.1	N. 40° 30′ E.	6.3	10 a.m.	12 m.	1.00	30
.106	48	15.1	15.0	6.4	26.4	N. 89° 43′ E.	20.0	0	0	0	31
748.061	2241	1324.5	514.3	377.0	539.9	....	.....	.....	.....	2.14	......
24.131	72.3	......	......	......	......	....	.....	.....	.....	.....	......
....	......	......	......	......	......	....	.....	.....	.....	.....	......

MONTHLY SUMMARY OF

SEPTEMBER,

Date.	Thermometers.					Psychrometer.						Sunshine Recor[d]		
	Temperatures.			Hours of Extremes.		Relative Humidity.			Dew-point.			Clouds at Observ'n.	Number of Minutes.	
	Mean of 24 h.	Extremes.												
		Max.	Min.	Max.	Min.	6 A.M.	12 M.	6 P.M.	6 A.M.	12 M.	6 P.M.		Act-ual.	Pos-sible
1	66.7	80	54	2 p.m.	2 a.m.	78	33	36	49	44	43	5	635	745
2	55.2	60	54	1 a.m.	6 a.m.	89	74	83	52	50	49	25	0	742
3	52.1	56	50	4 p.m.	5 a.m.	88	83	89	49	48	51	26	0	739
4	59.6	76	47	3 p.m.	5 a.m.	94	49	64	48	52	54	14	598	737
5	63.4	78	50	2 p.m.	6 a.m.	83	29	38	48	41	44	2	569	734
6	65.6	80	52	1 p.m.	5 a.m.	64	32	25	45	45	39	6	515	732
7	66.1	81	50	1 p.m.	5 a.m.	71	27	31	64	42	41	0	642	729
8	65.0	80	49	1 p.m.	5 a.m.	47	32	31	39	47	38	9	426	725
9	65.5	83	52	1 p.m.	5 a.m.	73	30	60	46	46	50	15	507	722
10	66.5	82	51	2 p.m.	5 a.m.	69	25	30	48	39	42	5	658	720
11	61.1	73	53	3 p.m.	6 a.m.	83	54	68	49	52	53	10	568	715
12	58.4	68	49	3 p.m.	4 a.m.	62	51	58	41	45	48	6	635	711
13	59.5	75	41	5 p.m.	6 a.m.	60	52	41	30	48	45	2	550	706
14	59.1	70	50	1 p.m.	7 a.m.	94	30	33	50	37	33	17	488	704
15	59.3	75	48	2 p.m.	6 a.m.	49	59	51	32	57	41	22	561	702
16	44.5	50	41	2 p.m.	4 a.m.	73	87	67	36	42	33	23	152	700
17	46.8	55	41	....	6 a.m.	100	66	70	42	41	41	29	198	697
18	48.2	62	38	1 p.m.	6 a.m.	81	36	81	34	33	41	18	475	696
19	50.5	65	41	1 p.m.	1 a.m.	80	35	70	39	36	41	11	463	694
20	57.7	74	43	2 p.m.	6 a.m.	80	36	37	40	40	39	1	656	693
21	60.4	78	42	2 p.m.	3 a.m.	74	26	31	37	38	35	4	490	690
22	57.6	73	45	1 p.m.	6 a.m.	68	37	69	36	43	47	14	397	689
23	58.0	72	43	1 p.m.	6 a.m.	87	44	52	41	47	48	8	522	687
24	60.7	76	45	....	4 a.m.	70	23	42	41	33	43	16	425	685
25	63.8	75	49	12 m.	3 a.m.	57	39	61	40	45	55	7	518	681
26	45.4	57	41	1 a.m.	10 a.m.	87	86	93	43	40	41	29	0	679
27	46.5	53	42	6 p.m.	6 a.m.	100	94	88	43	45	50	29	0	675
28	58.0	71	45	3 p.m.	1 a.m.	69	24	46	37	32	42	0	610	671
29	53.2	64	41	2 p.m.	5 a.m.	86	58	60	38	48	45	1	565	668
30	55.7	69	40	2 p.m.	5 a.m.	86	45	54	37	44	46	10	555	666
Sums,	1730.1	2111	1387	....	....	2212	1396	1659	1274	1300	1218	364	.....	.....
Means,	57.7	70.4	46.2	....	....	74	47	55	42	43	41	12	.....	.....
Perctg.	......	......	......	....	....	.....	.....	.....	.....	.....	.....	40%	.....	.....

*361 miles is the total velocity of two days, the 17th and 18th. The components

INSTRUMENTAL RECORD.

1906.

BAROM.	ANEMOMETER AND ANEMOSCOPE.							RAIN GAUGE.			DATE.
	WIND.							Hours of Fall.		Total Amount.	
Actual Pressure at 12 M.	Total Velocity.	Sum of Components.				Equivalent.		Earliest.	Latest.		
		N.	S.	W.	E.	Direction.	Miles.				
24.044	54	36.1	8.7	5.6	15.0	N. 18° 56′ E.	29.0	0	0	0	1
.173	101	93.0	0	22.8	4.0	N. 11° 26′ W.	94.9	10 a.m.	3 p.m.	.07	2
.202	55	22.3	19.8	11.8	16.5	N. 62° 00′ E.	5.3	2 a.m.	4 a.m.	.02	3
.132	43	17.3	17.6	0.6	16.8	S. 88° 56′ E	16.2	0	0	0	4
.268	56	35.3	12.7	1.4	17.0	N. 34° 37′ E.	27.4	0	0	0	5
.220	50	29.1	14.2	3.4	14.4	N. 36° 26′ E.	18.5	0	0	0	6
.211	43	20.9	16.6	1.4	13.1	N. 69° 49′ E.	12.5	0	0	0	7
.144	51	27.0	9.9	19.1	8.0	N. 32° 59′ W.	20.4	0	0	0	8
.057	66	45.1	3.9	23.1	6.4	N. 22° 04′ W.	44.4	6 p.m.	6 p.m.	.20	9
.053	67	50.7	9.8	9.2	11.7	N. 3° 30′ E.	41.0	0	0	0	10
.085	73	49.2	16.0	9.0	14.1	N. 8° 44′ E.	33.6	6 p.m.	6 p.m	T	11
.195	83	32.7	37.4	8.4	32.6	S. 79° 01′ E.	24.7	0	0	0	12
.015	61	6.5	35.9	5.6	31.8	S. 41° 42′ E.	39.4	0	0	0	13
23.676	105	0.3	70.3	25.7	43.5	S. 14° 15′ E.	72.2	....	....	T	14
.884	336	136.1	142.4	89.6	74.2	S. 67° 45′ W.	16.6	11 p.m	11 p.m.	.06	15
24.177	302	296.5	0	36.2	11.6	N. 4° 45′ W.	297.5	7 a.m.	12 n't	.10	16
.248	*361	14.5	56.2	6.0	54.8	S. 49° 29′ E.	64.2	1 a.m.	4 p.m.	.11	17
.236	......	145.8	0	52.9	47.7	N. 2° 03′ W.	145.9	7 p.m	7 p.m.	.01	18
.183	256	225.7	6.5	26.1	52.8	N. 6° 56′ E.	220.8	3 p.m.	4 p.m.	.03	19
.124	125	110.6	0.7	10.9	21.7	N. 5° 37′ E.	110.4	0	0	0	20
.191	115	91.8	6.0	7.7	21.6	N. 9° 12′ E	86.9	0	0	0	21
.269	152	64.5	55.6	30.6	33.1	N. 15° 41′ E.	9.2	5 p.m.	7 p.m.	.07	22
.174	139	53.3	57.4	8.4	60.6	S. 85° 31′ E.	52.4	0	0	0	23
.031	149	74.0	47.8	45.4	12.4	N. 51° 33′ W.	42.1	0	0	0	24
.058	135	72.5	17.6	10.7	68.3	N. 46° 23′ E.	79.5	0	0	0	25
.368	208	146.6	37.9	32.1	39.4	N. 3° 51′ E.	109.0	5 a.m.	11 p.m	1.24	26
.223	174	36.0	94.9	24.0	81.7	S. 44° 25′ E.	82.5	1 a.m.	2 a.m.	.03	27
.219	193	184.6	0	20.9	21.8	N. 0° 17′ E.	184.6	0	0	0	28
.418	151	40.2	78.7	0	78.4	S. 63° 51′ E.	87.3	0	0	0	29
.315	118	58.0	40.0	8.8	40.0	N. 60° 01′ E.	36.0	6 a.m.	6 a.m.	.02	30
724.593	3822	2216.2	914.5	557.4	965.0	....	......	....	....	1.96	.....
24.153	127.4	.....	......	......	......	....	......	....	....	....	....
....	....	....	....	....	....	....	......	....	....	....	....

lacking for 13 hours, beginning 7 P. M. of the 17th, during which the run was 71 miles.

MONTHLY SUMMARY OF

OCTOBER,

DATE.	THERMOMETERS.					PSYCHROMETER.						SUNSHINE REC'D'R			
	TEMPERATURES.			Hours of Extremes.		Relative Humidity.			Dew-point.			Clouds at Observ'n.	Number of Minutes.		
	Mean of 24 h.	Extremes. Max.	Extremes. Min.	Max.	Min.	6 A.M.	12 M.	6 P.M.	6 A.M.	12 M.	6 P.M.		Act-ual.	Pos-sible.	Pe ct
1	60.0	73	47	3 p.m.	3 a.m.	70	21	38	39	30	37	6	567	664	8
2	59.6	76	46	12 m.	12 n't	59	22	37	35	34	36	5	557	662	8
3	61.5	79	44	4 p.m.	12 n't	46	22	41	32	34	45	3	593	660	9
4	37.4	44	32	1 a.m.	1 p.m.	63	100	84	28	32	33	26	0	656	
5	42.5	56	29	4 p.m.	6 a.m.	81	42	49	26	28	32	0	587	655	9
6	51.5	69	33	3 p.m.	2 a.m.	77	24	36	33	28	33	0	594	653	9
7	58.2	75	40	2 p.m.	3 a.m.	45	26	27	26	36	27	3	594	651	9
8	58.6	69	42	3 p.m.	12 n't	42	26	38	28	31	32	0	555	647	8
9	46.8	61	33	4 p.m.	6 a.m.	91	49	48	32	37	36	0	600	645	9
10	52.6	71	34	4 p.m.	6 a.m.	83	26	41	31	31	37	0	540	642	8
11	59.5	76	42	1 p.m.	2 a.m.	45	23	26	30	33	29	0	540	639	8
12	60.3	74	44	1 p.m.	3 a.m.	31	14	31	23	21	32	11	527	635	8
13	42.8	55	34	1 a.m.	6 a.m.	92	86	68	34	36	34	28	0	633	
14	43.6	54	34	5 p.m.	12 n't	86	47	57	36	29	32	18	78	631	1
15	46.5	66	32	4 p.m.	7 a.m.	100	32	47	33	31	34	12	600	629	9
16	49.5	67	34	2 p.m.	5 a.m.	75	34	.....	29	37	.....	0	590	626	9
17	45.4	55	39	3 p.m	5 a.m.	63	56	72	35	37	34	12	220	624	3
18	43.2	55	31	4 p.m.	6 a.m.	90	40	52	29	27	31	0	583	620	9
19	45.0	63	31	4 p.m.	4 a.m.	59	46	49	23	36	32	2	578	617	9
20	30.6	40	23	1 a.m.	12 n't	91	91	89	30	30	24	28	0	614	
21	20.8	25	18	1 a.m.	7 p.m.	75	74	86	16	15	15	30	0	612	
22	21.8	25	16	2 p.m.	4 a.m.	86	66	74	16	16	15	19	433	608	7
23	27.7	35	21	2 p.m.	1 a.m.	77	66	90	18	25	28	19	0	606	
24	40.4	58	19	3 p.m.	1 a.m.	67	32	36	17	24	23	0	441	604	7
25	49.9	58	40	3 p.m.	3 a.m.	38	28	53	22	25	33	15	348	601	5
26	52.8	68	38	3 p.m.	12 n't	42	55	41	28	41	33	12	470	597	7
27	41.2	51	32	3 p.m.	12 n't	76	52	55	30	31	30	13	386	596	6
28	50.2	70	30	3 p.m.	6 a.m.	80	30	31	25	34	27	1	562	595	9
29	41.0	52	31	1 a.m.	12 n't	99	49	66	29	28	31	7	490	592	8
30	40.4	55	26	1 p.m.	4 a.m.	69	38	50	20	29	29	0	280	589	4
31	44.5	60	30	2 p.m.	3 a.m	72	19	46	25	18	33	2	560	588	9
Sums,	1425.8	1835	1025	....	....	2170	1336	1558	858	924	927	272	.....	.....	20
Means,	46.0	59.2	33.1	....	....	70	43	52*	28	30	31*	9	.....	.....	..
Perctg.	......	......	......	....	....	.....	.....	.....	.....	.....	.....	30%	...	.....	6

†The record of October sunshine is from the Knob Hill photographic register. * For 30 days.

INSTRUMENTAL RECORD.

1906.

Barom.	Anemometer and Anemoscope.							Rain Gauge.			
	Wind.							Hours of Fall.		Total Amount.	Date.
Actual Pressure at 12 M.	Total Velocity.	Sum of Components.				Equivalent.					
		N.	S.	W.	E.	Direction.	Miles.	Earliest.	Latest.		
24.147	177	163.8	0	28.0	25.0	N. 1° 03′ W.	163.8	0	0	0	1
.096	137	101.6	23.4	15.3	12.3	N. 2° 12′ W.	78.2	0	0	0	2
23.846	203	142.7	44.4	19.4	23.8	N. 2° 34′ E.	98.4	0	0	0	3
24.097	275	234.2	5.2	98.1	4.3	N. 22° 16′ W.	247.5	7 a.m.	3 p.m.	.11	4
.150	124	81.7	20.7	17.7	33.2	N. 14° 15′ E.	62.9	0	0	0	5
.224	182	91.0	62.8	6.6	64.7	N. 64° 07′ E.	64.6	0	0	0	6
.090	155	131.0	0.2	50.3	13.6	N. 15° 40′ W.	135.9	0	0	0	7
.193	191	91.6	55.8	38.4	64.5	N. 36° 06′ E.	44.3	0	0	0	8
.321	107	42.8	48.4	1.2	39.8	S. 81° 45′ E.	39.0	0	0	0	9
.173	164	81.3	61.1	3.3	56.6	N. 69° 15′ E.	57.0	0	0	0	10
.035	147	101.7	29.0	19.7	23.4	N. 2° 55′ E.	72.7	0	0	0	11
23.879	170	123.7	19.0	46.3	20.5	N. 13° 51′ W.	107.8	0	0	0	12
24.135	328	280.3	0	136.9	2.5	N. 25° 37′ W.	310.9	....	....	.51	13
.119	157	133.5	0.5	47.1	12.5	N. 14° 35′ W.	137.4	0	0	0	14
.100	140	112.9	7.0	5.7	43.1	N. 19° 27′ E.	112.3	0	0	0	15
23.899	124	52.5	47.8	3.3	49.4	N. 84° 11′ E.	46.4	0	0	0	16
.849	182	88.9	40.4	11.0	75.2	N. 52° 56′ E.	80.4	0	0	0	17
24.015	147	63.3	57.5	6.5	63.0	N. 84° 08′ E.	56.6	0	0	0	18
23.872	286	221.9	47.8	18.8	50.8	N. 10° 25′ E.	177.0	0	0	0	19
24.030	495	457.1	0	122.9	4.8	N. 13° 40′ W.	470.4	......	....	T	20
.267	515	449.9	0	236.0	0	N. 27° 41′ W.	508.1	....	....	.25	21
.110	407	382.0	0	80.1	22.6	N. 8° 34′ W.	386.2	....	....	.15	22
.010	428	335.9	3.7	211.0	8.8	N. 31° 20′ W.	388.9	0	0	0	23
.141	123	57.5	29.4	15.6	52.3	N. 52° 34′ E.	46.2	0	0	0	24
.095	139	40.4	56.0	29.3	64.9	S. 66° 20′ E.	38.8	0	0	0	25
.040	200	86.5	63.7	12.9	69.1	N. 67° 55′ E.	60.6	0	0	0	26
.375	138	39.0	69.3	1.3	70.3	S. 66° 18′ E.	75.3	0	0	0	27
.058	164	131.1	11.4	42.5	14.2	N. 13° 18′ W.	123.0	0	0	0	28
.203	200	104.7	51.7	14.4	84.1	N. 52° 45′ E.	87.5	0	0	0	29
.223	112	59.2	38.8	0.8	36.2	N. 60° 03′ E.	40.8	0	0	0	30
.133	148	69.7	50.6	5.2	57.9	N. 70° 05′ E.	56 0	0	0	0	31
746.925	6465	4553.4	945.6	1345.6	1163.4	....	......	......	......	1.02	.....
24.094	208.5	......	......	......	......	....	......	......	......	......	.....

MONTHLY SUMMARY OF

NOVEMBER,

	THERMOMETERS.					PSYCHROMETER.						SUNSHINE RECORD			
DATE.	TEMPERATURES.			Hours of Extremes.		Relative Humidity.			Dew-point.			Clouds at Observ'n.	Number of Minutes.		P c
	Mean of 24 h.	Extremes. Max.	Min.	Max.	Min.	6 A.M.	12 M.	6 P.M.	6 A.M.	12 M.	6 P.M.		Actual.	Possible.	
1	45.8	60	37	1 p.m.	2 a.m.	77	46	47	32	37	34	25	198	586	3
2	33.1	39	29	1 a.m.	12 n't	74	74	80	27	27	25	18	85	582	1
3	31.2	44	27	4 p.m.	7 a.m.	89	90	82	24	29	30	19	208	579	3
4	45.6	59	28	3 p.m.	2 a.m.	16	27	36	24	23	26	2	545	578	9
5	49.1	67	33	3 p.m.	4 a.m	76	20	28	30	22	25	9	468	576	8
6	45.8	55	30	11 a.m.	12 n't	50	46	55	29	32	30	14	320	574	5
7	41.8	60	25	3 p.m.	6 a.m.	89	22	52	22	20	31	5	527	572	9
8	51.4	69	35	2 p.m.	12 n't	29	21	14	18	25	29	2	480	570	8
9	39.2	52	27	4 p.m.	6 a.m.	90	62	66	28	34	31	17	108	568	1
10	52.5	65	40	3 p.m.	3 a.m.	60	20	....	44	22	....	2	533	566	9
11	42.8	54	29	2 p.m.	12 n't	65	40	52	30	27	26	4	431	565	7
12	46.1	65	24	3 p.m.	5 a.m.	79	18	22	22	19	16	13	364	563	6
13	53.8	64	34	2 p.m.	12 n't	25	9	61	25	5	32	17	215	561	3
14	48.0	67	31	2 p.m.	8 a.m.	100	19	32	32	23	28	11	455	560	8
15	50.3	67	33	4 p.m.	8 a.m.	95	43	21	33	31	22	10	262	558	4
16	41.4	58	27	1 a.m.	12 n't	32	19	54	15	6	23	8	....	556	...
17	24.4	28	18	1 a.m.	8 a.m.	88	88	88	20	21	20	26	165	554	3
18	15.0	22	11	1 a.m.	12 n't	93	83	93	13	9	9	30	142	552	2
19	7.3	13	3	1 a.m.	12 n't	95	84	96	1	5	6	20	126	551	2
20	8.0	20	6	3 p.m.	3 a.m.	93	95	96	6	15	8	0	463	549	8
21	24.6	35	11	4 p.m.	1 a.m.	88	39	65	21	13	15	8	503	548	9
22	25.8	30	17	2 p.m.	5 a.m.	88	59	78	19	17	21	25	297	547	5
23	23.3	28	17	4 p.m.	8 a.m.	93	88	....	18	19	....	20	32	545	
24	26.7	36	19	4 p.m.	7 a.m.	95	79	71	19	23	22	16	....	543	...
25	32.4	43	20	2 a.m.	12 n't	75	19	52	17	5	16	4	427	541	7
26	25.8	35	15	3 p.m.	7 a.m.	87	49	79	17	19	22	0	446	539	8
27	26.8	38	17	3 p.m.	7 a.m.	94	74	89	16	27	26	1	484	539	9
28	31.5	42	21	3 p.m.	7 a.m.	88	56	82	21	25	30	4	485	537	9
29	38.3	55	26	2 p.m.	2 a.m.	60	34	52	18	25	26	0	492	537	9
30	32.1	35	26	3 p.m.	12 n't	96	66	85	31	25	26	27	0	536	
Sums,	1059.9	1405	698	....	....	2309	1489	1758	660	630	655	357	.....	.....	16
Means,	35.3	46.8	23.3	....	....	77	50	*63	22	21	*23	12	.....	.....	...
Perctg.	......	....	....	....	....	.....	.....	.....	.....	.....	.....	40%	....	....	*5

* For 28 days.

† Daily velocities from dial-readings.

INSTRUMENTAL RECORD.

1906.

BAROM.	ANEMOMETER AND ANEMOSCOPE.							RAIN GAUGE.			
	WIND.										
Actual Pressure at 12 M.	Total Velocity.	Sum of Components.				Equivalent.		Hours of Fall.		Total Amount.	Date.
		N.	S.	W.	E.	Direction.	Miles.	Earliest.	Latest.		
23.933	210	156.3	22.3	20.0	51.4	N. 13° 11′ E.	137.6	0	0	0	1
24.159	431	418.7	0	46.3	29.4	N. 2° 19′ W.	419.0	0	0	T	2
.145	99	22.2	46.7	11.6	51.1	S. 58° 11′ E.	46.4	0	0	0	3
.158	182	39.8	105.6	15.9	81.5	S. 44°′55 E.	92.9	0	0	0	4
23.931	113	66.3	33.6	18.1	16.7	N. 2° 27′ W.	32.7	0	0	0	5
24.100	180	158.3	8.8	23.5	31.0	N. 2° 52′ E.	149.9	0	0	0	6
.169	139	92.1	31.0	9.3	33.7	N. 21° 46′ E.	65.8	0	0	0	7
.107	131	77.8	28.5	16.6	37.7	N. 23° 10′ E.	53.6	0	0	0	8
.209	79	69.7	2.0	8.5	10.6	N. 1° 47′ E.	67.7	0	0	0	9
.155	†247	......	......	......	......	....	......	0	0	0	10
.262	151	87.2	40.4	13.0	44.6	N. 34° 02′ E.	56.4	0	0	0	11
.162	244	184.6	5.5	77.0	33.5	N. 13° 39′ W.	184.3	0	0	0	12
23.818	474	286.2	51.7	227.7	76.7	N. 32° 47′ W.	278.9	0	0	0	13
.827	198	85.5	48.3	64.3	51.9	N. 18° 26′ W.	39.2	0	0	0	14
.659	223	42.9	54.1	111.4	71.6	S. 74° 17′ W.	41.3	0	0	0	15
.583	†461	......	......	......	......	....	......	0	0	0	16
.549	189	44.0	109.8	6.6	95.3	S. 53° 26′ E.	110.5	1 p.m.	5 p.m.	.01	17
.853	151	31.4	53.2	3.3	102.9	S. 77° 38′ E.	101.9	....	....	.30	18
24.147	110	27.8	48.4	0.4	68.7	S. 73° 13′ E.	71.3	....	....	.04	19
23.903	143	56.3	57.2	3.1	65.1	S. 89° 10′ E.	62.0	....	....	T	20
.858	122	89.1	15.2	17.0	20.3	N. 2° 33′ E.	74.0	0	0	0	21
24.036	170	167.3	0	12.4	7.4	N. 1° 43′ W.	167.4	....	....	T	22
.279	‡201	......	......	......	......	....	......	0	0	0	23
.033	......	......	......	......	......	....	......	0	0	0	24
23.766	280	179.6	6.0	175.1	2.1	N. 44° 54′ W.	245.1	0	0	0	25
24.217	152	59.8	77.1	11.9	31.2	S. 48° 08′ E.	25.9	0	0	0	26
.338	103	73.6	21.5	4.5	17.7	N. 14° 13′ E.	53.7	0	0	0	27
.121	117	76.3	23.5	4.1	36.2	N. 31° 18′ E.	53.7	0	0	0	28
23.973	189	134.0	43.2	17.7	26.1	N. 5° 17′ E.	91.2	0	0	0	29
24.167	142	96.7	29.9	1.3	47.2	N. 34° 30′ E.	81.0	0	0	0	30
720.617	5631	2823.5	963.5	920.6	1141.6	....	......	....	....	0.35	......
24.021	187.7	......	......	......	......	....	......	....	....	......	......

Total velocity for 23d and 24th, together, from dial. 31

MONTHLY SUMMARY OF

DECEMBER.

Date.	Thermometers. Temperatures. Mean of 24 h.	Extremes. Max.	Extremes. Min.	Hours of Extremes. Max.	Hours of Extremes. Min.	Psychrometer. Relative Humidity. 6 A.M.	Relative Humidity. 12 M.	Relative Humidity. 6 P.M.	Dew-point. 6 A.M.	Dew-point. 12 M.	Dew-point. 6 P.M.	Sunshine Record. Clouds at Observ'n.	Number of Minutes. Actual.	Number of Minutes. Possible
1	30.7	45	24	4 p.m.	8 a.m.	90	100	69	22	27	28	21	156	535
2	46.2	62	34	2 p.m.	1 a.m.	52	30	..	26	28	....	15	130	535
3	47.0	58	35	3 p.m.	2 a.m.	47	45	51	25	35	30	6	346	533
4	42.7	56	31	1 p.m.	12 n't	84	26	47	33	22	25	5	451	533
5	43.7	52	36	3 p.m.	1 a.m.	57	26	26	27	16	16	8	406	532
6	36.4	46	26	4 p.m.	7 a.m.	77	51	20	20	25	39	0	486	532
7	43.1	68	32	3 p.m.	1 a.m.	59	18	17	23	21	10	2	486	530
8	42.9	54	30	1 p.m.	12 n't	31	14	29	11	8	11	7	425	530
9	39.2	53	23	2 p.m.	4 a.m.	56	22	37	14	18	20	3	470	528
10	35.5	50	26	3 p.m.	6 a.m.	79	36	57	22	23	27	5	343	528
11	48.8	63	34	8 p.m.	2 a.m.	46	36	19	19	26	20	14	39	528
12	51.0	60	40	2 p.m.	7 a.m.	39	24	32	23	22	24	21	165	528
13	41.6	49	30	4 a.m.	12 n't	22	15	26	11	4	9	0	472	526
14	26.0	34	16	3 p.m.	12 n't	94	61	47	22	20	10	8	380	526
15	18.6	28	9	3 p.m.	12 n't	100	75	16	86	17	15	10	435	526
16	21.0	32	8	2 p.m.	1 a.m.	56	27	51	5	4	8	0	385	526
17	20.2	36	8	12 m.	6 a.m.	100	79	8	52	24	10	0	457	525
18	25.8	41	11	2 p.m.	6 a.m.	83	40	52	10	18	16	10	429	525
19	37.7	48	28	1 p.m.	12 n't	59	19	39	23	9	13	12	277	525
20	41.7	53	22	3 p.m.	6 a.m.	60	27	24	13	18	16	13	344	525
21	44.5	56	27	12 m.	12 n't	51	25	35	20	20	19	1	479	524
22	37.2	57	21	12 m.	6 a.m.	88	24	44	19	22	21	0	471	524
23	43.8	63	27	3 p.m.	1 a.m.	33	15	16	10	16	7	14	275	525
24	40.9	54	26	2 p.m.	12 n't	25	19	40	10	13	21	8	266	525
25	36.5	54	23	2 p.m	6 a.m.	75	42	52	17	28	21	6	439	525
26	48.6	60	39	3 p.m.	4 a.m.	29	25	44	14	24	29	8	252	525
27	46.2	56	30	2 p.m.	12 n't	57	31	50	32	23	29	4	420	526
28	32.7	40	23	1 p.m.	8 a.m.	66	57	46	16	27	19	21	0	526
29	34.6	40	30	2 p.m.	1 a.m.	75	55	73	28	24	26	21	14	527
30	32.2	47	22	3 p.m.	7 a.m.	88	31	73	19	16	26	13	465	527
31	23.5	30	17	1 p.m.	7 a.m.	59	33	77	8	13	20	17	15	528
Sums,	1165.5	1550	791	......	......	1988	1128	1217	680	591	575	273	.....	.....
Means,	37.6	50.0	25.5	......	......	64	36	41*	22	19	19*	9	.....	.....
Perctg.	......	......	......	......	......	......	......	......	......	......	......	29%	.....	.....

* For 30 days.

INSTRUMENTAL RECORD.

1906.

Barom.	Anemometer and Anemoscope.							Rain Gauge.			Date.
	Wind.							Hours of Fall.		Total Amount.	
Actual Pressure at 12 m.	Total Velocity.	Sum of Components.				Equivalent.		Earliest.	Latest.		
		N.	S.	W.	E.	Direction.	Miles.				
24.275	121	48.2	46.4	6.1	55.6	N. 87° 55′ E.	49.5	0	0	0	1
.181	125	96.7	15.3	20.7	18.0	N. 1° 54′ W.	81.4	0	0	0	2
.163	119	77.9	30.2	1.9	29.0	N. 29° 36′ E.	54.9	0	0	0	3
23.802	225	96.3	42.2	89.7	6.2	N. 57° 04′ W.	99.5	....	5.30a.m	.06	4
.822	459	218.1	11.1	255.6	7.6	N. 50° 09′ W.	223.1	0	0	0	5
24.213	121	44.8	57.7	11.2	44.3	S. 68° 42′ E.	35.5	0	0	0	6
.034	121	87.1	23.0	35.0	1.1	N. 27° 52′ W.	72.5	0	0	0	7
23 .924	213	67.0	103.1	11.6	92.6	S. 65° 59′ E.	88. 7	0	0	0	8
24.003	113	67.1	31.3	27.9	15.0	N. 19° 49′ W.	38.1	0	0	0	9
.357	114	111.0	4.9	20.4	8.8	N. 6° 14′ W.	106.7	0	0	0	10
.192	181	101.5	47.7	44.7	25.8	N. 19° 22′ W.	57.0	0	0	0	11
23.931	237	58.5	141.1	39.8	68.6	S. 22° 15′ E.	89.2	0	0	0	12
.830	301	147.8	31.4	133.7	87.8	N. 21° 31′ W.	125.1	0	0	0	13
24.034	110	30.8	55.2	9.9	49.4	S. 58° 18′ E.	46.4	0	0	0	14
.083	162	53.2	83.8	9.8	58.7	S. 57° 58′ E.	57.7	....	....	.04	15
.056	221	214.6	0	13.9	21.8	N. 2° 07′ E.	244.7	0	0	0	16
.157	125	57.8	38.0	5.9	54.0	N. 67° 37′ E.	52.0	0	0	0	17
.091	103	75.1	20.6	11.9	14.3	N. 2° 31′ E.	54.6	0	0	0	18
23.926	308	244.8	0	150.5	17.8	N. 28° 28′ W.	278.4	0	0	0	19
.976	439	295.2	0	301.7	2.9	N. 45° 21′ W.	423.3	0	0	0	20
24.227	243	163.1	36.1	79.2	34.8	N. 19° 16′ W.	134.7	0	0	0	21
.383	149	100.7	29.8	5.6	31.8	N. 20° 17′ E.	75.6	0	0	0	22
.271	132	79.3	34.3	21.5	32.2	N. 13° 23′ E.	46.2	0	0	0	23
.136	147	111.6	18.2	17.2	19.5	N. 1° 24′ E.	93.4	0	0	0	24
.089	159	89.2	47.2	31.4	37.5	N. 8° 19′ E.	42.4	0	0	0	25
23.894	145	158.1	12.0	53.6	15.4	N. 14° 39′ W.	151.0	0	0	0	26
.892	284	188.6	13.4	172.9	16.3	N. 41° 48′ W.	235.0	0	0	0	27
.886	119	95.5	13.2	16.2	15.6	N. 0° 25′ W.	82.3	0	0	0	28
.726	385	360.1	0	64.7	15.8	N. 7° 44′ W.	362.3	0	0	0	29
.884	133	91.1	28.4	14.8	25.9	N. 10° 02′ E.	63.7	0	0	0	30
.785	115	42.7	58.6	4.4	40.2	S. 66° 03′ E.	39.2	0	0	0	31
745.273	5929	3654.5	1074.2	1678.4	964.3	....	....	Earliest.	Latest.	0.10	......
24.041	191.3	.....	....	....	....	....	....	....	....	....	......

MONTH.	BAROMETER. Mean at 12 M.	Extremes. Max.	Extremes. Min.	Dates of Extremes. Max.	Dates of Extremes. Min.	THERMOMETER. Mean.	Extremes. Max.	Extremes. Min.	Dates of Extremes. Max.	Dates of Extremes. Min.	Mean Max.	Mean Min.	ANEMOMETER. Wind. Mean Daily Velocity	Max. Daily Velocity	Date.
January	23.990	24.38	23.42	25	19	32.6	62	2	18[3]	21	46.1	18.9	218	708[1]	19
February	24.022	.33	.68	2	28	31.3	65	1	21	5	46.5	16.9	191	333	22
March	23.974	.32	.36[2]	7	1	27.8	64	5	31	19	39.2	17.3	208	408	1
April	.998	.32	.59	19	7	45.2	77	23	22	1	57.2	34.0	258	526	12
May	.970	.35	.67	8	24	53.9	79	32	16	7[6]	65.5	41.5	204	398	4
June	.988	.20	.74	11	6	61.4	91[1]	38	16	8	74.3	48.0	152	424	6
July	24.188	.36	24.06	2	18	62.9	88	42	21[3]	1	77.1	52.0	......	......	......
August	.131	.33	.02	26	19	65.5	86	45	21[3]	27[3]	79.7	52.2	72	141	3
September	.153	.42[1]	23.68	29	14	57.7	83	38	9	18	70.4	46.2	127	336	15
October	.094	.38	.85	27	3	46.0	79	16	3	22	59.2	33.1	208	515	21
November	.021	.34	.55	27	17	35.3	69	6[2]	8	20	46.8	23.3	188	474	13
December	.041	.38	.73	22	29	37.6	68	8	7	16[3]	50.0	25.5	191	459	5
Sums	288.570	292.11	284.35	......	......	557.2	......	......	......	......	712.0	408.9	2,017	......	......
Means	24.048	24.34	23.70	......	......	46.4	......	......	......	......	59.3	34.1	183[8]	......	......

MONTH.	PSYCHROMETER. Relative Humidity. 6 A.M.	12 M.	6 P.M.	Minimum Humidity.[5] Per ct.	Date.	Dew-point. 6 A.M.	12 M.	6 P.M.	PERCENTAGES OF CLOUD AND SUN. Cloud (Area)	Sunshine (Time)	RAIN GAUGE. Total Rain	Max. in one day.	Date.	NUMBER OF DAYS. Max. Th. below 32	Min. Th. below 32	Max. Th. above 80	Clear.	Part Cloudy	Cloudy	Rain.[4]
Jan.	56	40	54	13	5[6]	11	20	19	27	69	0.45	0.41	2	4	28	0	18	11	2	3
Feb.	65	35	45	4[2]	26	13	15	17	26	71	0.07	0.04	14	2	27	0	16	11	1	2
Mar.	79	60	65	10	13[7]	18	19	20	49	52	2.74	1.17	27	9	28	0	11	10	10	8
April	64	37	40	9	24	27	24	26	45	61	2.20	0.62	7	0	9	0	10	12	8	10
May	54	39	43	12	16	31	34	35	42	54	2.45	1.23	23	0	0	0	10	15	6	10
June	......	......	......	......	......	......	......	......	38	60	1.05	0.41	23	0	0	9	14	10	6	7
July	68	48	57	20	20	47	51	52	55	48	2.39	0.82	18	0	0	9	4	14	13	13
Aug.	65	39	50	24	28	46	48	50	35	66	2.14	1.00	30	0	0	17	15	13	3	15
Sept.	74	47	55	23	24	42	43	41	40	63	1.96	1.24[1]	26	0	0	3	14	9	7	12
Oct.	70	43	52	14	12	28	30	31	30	66	1.02	0.51	13	2	12	0	18	9	4	4
Nov.	77	50	63	9	13	22	21	23	40	59	0.35	0.30	18	6	24	0	14	9	7	3
Dec.	64	36	41	14	8	22	19	19	29	62	0.10	0.06	4	2	23	0	18	9	4	2
Sums,	736	474	565	......	......	310	324	333	456	728	16.92	......	......	25	151	38	162	132	71	89
Means,	67[8]	43[8]	51[8]	......	......	28[8]	29[8]	30[8]	38	61	......	......	......	......	......	......	......	......	......	......

[1] Yearly maximum. [2] Yearly minimum. [3] More than one date. [4] One-hundredth of an inch or more. [5] Recorded at the noon observation, unless otherwise noted. [6] At the 6 A. M. observation. [7] At the 6 P. M. observation. [8] For eleven months.

THE PALMER LIBRARY OF ASTRONOMY AND METEOROLOGY.

The gift of General Palmer to the Observatory for the year 1906, embraced an appropriation for books, and has led to the institution of a library at the Observatory, to which, with his consent, his name has been attached. The Palmer Library of Astronomy and Meteorology is an adjunct of the Coburn Library, the general library of the College, but, to a degree, independent. Every observatory has necessarily some books of its own, which must be kept in the building; such as the American Ephemeris, for instance, which has to be consulted at nearly every observation—besides celestial atlases, as well as such guides to telescopic objects, as Webb's or Smyth's, etc., etc.;—all of which it would be in the highest degree inconvenient to store in the main library building. Beside works of this class, a number of books useful for consultation in astronomical and meteorological matters have been obtained from time to time, from one source and another, by those concerned in the observations, among whom the late P. E. Doudna should be mentioned. The recent gift, enlarging the scope and utility of the collection previously at hand, has made apparent the necessity of a catalogue of the whole, which thus becomes the nucleus of an observatory library—a most important and valuable institution, which in the future will be of great benefit to both teachers and students. The appropriation has been applied not only to the purchase of new books, but to binding pamphlets, a scarcely less important aid to the convenience of their use. One remarkable instance of this kind, is No. 161, the volume of Annual Climatological Summaries for 1906, the material collected in which consisted originally of unbound sheets issued from more than forty offices of the United States Weather Bureau, but which, in a single volume, enables the student to turn at once to specific information concerning the normal temperature and rainfall of nearly every county throughout the extent of the United States, including Hawaii and Porto Rico, (not Alaska), and furnishes at the same time the addresses of observers who may be consulted in regard to the original sources of information.

Among the books purchased, were some from the library of a European astronomer, recently deceased, illustrating in a most interesting manner, the important steps in the history of his science. It is intended to make some of these subjects of essays and reviews by students, which, in case of special interest, may be included in the College publication. One such paper by Miss Marie Antoinette Sahm, is presented in this number. It deals with a small volume, just three hundred years old, setting forth the Ptolemaic system of the universe as it was understood by one of the latest of its adherents, Oronce Fine, otherwise known as Orontius. To read such a volume places one, more convincingly than can easily be done otherwise, in the atmosphere of a former age, when all the fabric of modern science was as yet unwrought.

The appended list, as will be understood from the foregoing account, is in no sense a catalogue of the Palmer Library, nor even of that portion of it recently received from General Palmer, but is confined to certain bound volumes embraced in his gift. The reader will notice in it new works by authors of repute, like No. 6, and older treatises which made epochs in the history of science, like No. 3. Nor has the selection been confined to meteorology and astronomy, in their narrower sense, since mathematical and physical works, like Nos. 9, 23, 117 are included.

Still more recently, the same donor has added to the library a collection of 100 lantern slides, published by the Geographical Society of Chicago, illustrating meteorology in all its phases.

Partial List of Accessions, Bound Volumes.

No.	Author.	Title.
1	Fine, Oronce	La Theorique des Cieux et sept Planetes.
2	Lambert, J. H.	Description d'une Table Ecliptique.
3	Gauss, C. F	Theoria Motus Corporum Coelestium.
4	Asten, E	Determinatio Orbitae Grandis Cometae.
5	Secchi, P. A.	Die Sonne.
6	Clerke, Agnes M	Problems in Astrophysics.
7	Clerke, Agnes M	Modern Cosmogonies.
8	Lindenau, B	Tabulae Martis.
9	Plücker, Julius	Analytische Geometrie.
10	Legendre, A. M	Des Comètes.
11	Archimedis	Opera.
12	Bonwick, J.	Orion and Sirius.
13	Doppler, Christian	Ueber das Farbige Licht der Doppelsterne.
14	Nasmyth & Carpenter	Der Mond.
15	Marth, A	Data for Physical Observations of Planets.
16	Marth, A	Volume 2.
17	Hann, Julius	Handbuch der Klimatologie.
18	Hann, Julius	Volume 2.
19	Epping, J	Astronomisches aus Babylon.
20	Herschel, Wm	The Sidereal Part of the Heavens.
21	Wackerbarth *et al.*	Orbital and Physical Researches.
22	Schiaparelli *et al.*	Mars.
23	Poncelet, J. V	Traité des Propriétés Projectives des Figures
24	Poncelet, J. V	Volume 2.
25	Gore, J. E., & Davis, H. S.	Binary Stars. 61 Cygni.
26	Terby, F.; Schur, W.	Mars.
27	Sundry Authors	Mars, Asteroids, and Jupiter.
49	Barnes, Howard T.	Ice Formation.
117	Rutherford, E.	Radio-activity.
118	Heath, Thos. E.	Our Stellar Universe.
119	Allen, Richard H.	Star Names and their Meanings.
120	Hayford, John F.	A Text-book of Geodetic Astronomy.
121	Maunder, E. W.	The Royal Observatory, Greenwich.
122	Lowell, Percival	The Solar System.
123	Clerke, Agnes M. *et al.*	The Concise Knowledge of Astronomy.
146	Plateau, J.	Recherches sur les Figures d'Equilibre.
147	Abney, W. DeW.	Transmission of Sunlight.
156	Kayser, H.	Handbuch der Spectrosopie.

ORONCE FINE:

"La Theorique des Cieux et Sept Planetes."

Published at Paris in 1607.

By Marie A. Sahm.

Oronce Fine, mathematician and astronomer, was born at Briancon, in 1494, and died at Paris in 1555. He established a great reputation for himself by giving public lectures on mathematics, and while his fame was not lasting, he deserves much merit for having spread the knowledge, and inculcated more taste for the study of the exact sciences. "At that time," Johnson says, "very few mathematical works were printed and the manuscripts were much scattered and not easily accessible. Furthermore, during the last centuries, mathematical science had been very much mixed up with cabalistic elements and it was due to Fine's numerous publications that the study was restored to its scientific basis."

In spite of his great reputation, Fine lived in constant poverty; he was obliged to sell nearly all of his mathematical and astronomical instruments in order to maintain himself and family.

In 1532 a chair of mathematics was created for him at the College de France. Here, in the same year, he wrote his best work, entitled, "Protomathesis," consisting of four books on arithmetic, two on geometry, five on cosmography and four on gnomics. Later there followed "Quadrans Astrolabicus Aequatorium Planetarum," and La Theorique des Cieux.

In the science of astronomy, Fine was not so progressive; he did not advance any new thought, but accepted the Ptolemaic System in its completeness. This is a surprising fact, for at that time the Copernican Theory had already spread and was being accepted by many scientists. Fine rejected the new theory, as did his contemporary, Tycho

Brahe, although for what reasons is not known. His book, "*La Theorique des Cieux et Sept Planetes*," was published after his death. In it he gives at first, a brief description of the universe which he divides into two parts, i. e., the elementary region, comprising the four simple elements, fire, air, water and earth, and the celestial or superior region, comprising the planets and fixed stars. The earth, the most stable of the elements, holds the lowest place and supports water, the second in order; above water is placed air and then fire. Far beyond the zone of fire, move the heavens of the planets, each heaven containing an immense crystalline spherical shell, the smallest enclosing the earth and its superincumbent elements, and the larger spheres enclosing the smaller ones. The first, or innermost sphere is that of the moon, and after it in order, come those of Mercury, Venus, the Sun, Mars, Jupiter, Saturn, and the Fixed Stars, eight spheres in all.

Later astronomers had added a ninth sphere, the motion of which should produce the precession of the equinoxes, and a tenth, to cause the alternation of day and night. But Fine accepts only eight spheres, as he shows in his diagrams.* He discusses first, the sphere of the sun as "*the most worthy planet*," and also because its movement is easier to comprehend. The moon, more complex in its movements, is treated more at length and the description is again a careful exposition of the Ptolemaic theory. Fine dwells particularly upon the *evection* of the moon, *i. e.*, the inequality of the moon's motion at the quarters, due to variation of the position of the apsides. Ptolemy had discovered that the eccentricity of the lunar orbit is itself subject to an annual variation, depending on the motion of the lines of the apsides. Fine explains the motion of the eccentric or deferent from west to east according to the twelve signs of the Zodiac, and uses the deferent and epicyle of Ptolemy as an explanation of the inequality of the

* The frontispiece is a reproduction of one of Fine's diagrams, and exhibits both the elements and the planetary and sidereal spheres, as above described.

motion. The deferent carrying the epicycle is itself a moving eccentric circle, the centre of which revolves around the earth.

The *nodes of the moon* are called head and tail of the Dragon. Where the eccentric of the moon crosses the ecliptic from south to north, (ascending node,) is the head,—the descending node is called the tail. The name "draconitic" month is given to the period (about 27 days 5 hours) during which the moon returns to the same position with respect to the nodes. These names are interesting as a remnant of a very early superstition. Eclipses, which always occur near the nodes, were at one time supposed to be caused by a dragon, which devoured the sun or moon. The symbols still used to denote the two nodes, are supposed to represent the head and tail of the dragon.

A discussion of the *parallax* shows that the means employed for obtaining it were substantially the same as employed at present, *i. e.*, by finding the difference in the moon's direction as seen from two points on the earth whose distance apart is known.

As the moon's path is inclined to the ecliptic, the latitudes of the sun and moon may differ by as much as 5° either when they are in conjunction—*i. e.*, when they have the same longitude—or when they are in opposition. Eclipses take place if, and only if the distance of the moon from a node at the time of conjunction or opposition lies within certain limits approximately known; and so the problem of predicting eclipses could be roughly solved by such knowledge of the moon and of its nodes as Oronce Fine possessed.

The treatment of the other planets is analogous to that of the moon. Each planet describes an epicycle, for only this theory can account for the sometimes direct, sometimes retrograde, and sometimes altogether arrested motion of the planets. According to this hypothesis, while a planet was moving in a small circle, the centre of that small circle was describing a larger circle about the earth. This larger circle was called the deferent, and the smaller, which was borne upon it, was called the epicycle. In this way, the motions of the planets were conceived to be something like what the motion of the moon about the sun actually is. By assuming proper proportions between the radii of the deferent circle and the earth, and between the velocities of the two motions, the astronomers through the Middle Ages found it possible to explain to their satisfaction, the irregularities in the motions of the planets. But as neither the consequences of elliptic motions of the planets around the sun nor the irregularities of the moon's motion could be adequately explained, the astronomers down to Tycho Brahe continued to increase the number of epicycles, setting one circle upon another, until the whole system became extremely complicated.

Oronce Fine, however, seems to have been satisfied with the single epicycle hypothesis, in his discussion of the planets, especially the superior planets, Saturn, Jupiter and Mars. By using the *equant* introduced first by Ptolemy, he believed it possible to represent with very fair exactitude, the motions of the planets, as given by the observations in his possession.

Fine was necessarily handicapped in his observations, lacking the use of the telescope,—an instrument which appeared about fifty years after his death.